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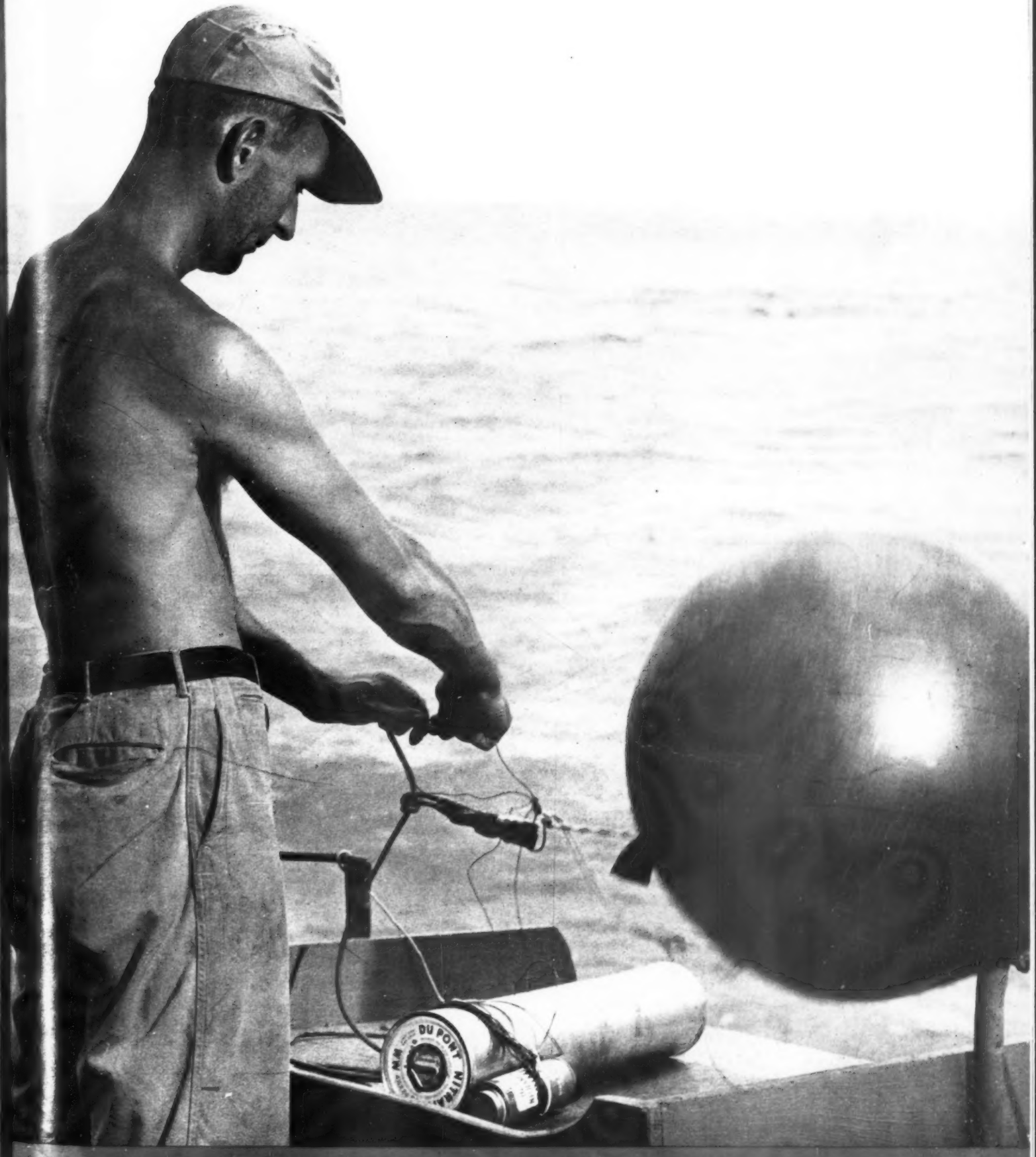

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WORLD PETROLEUM

Founded by Russell Palmer

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THIS MONTH'S COVER. Harry J. Maloy, assistant shooter aboard Humble Oil & Refining Company's explosives ship "Careless" connects wires of Nitramon primer with shooting wire before throwing explosive charge overboard. Photo by Lee for Standard Oil Co. (N. J.).

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OIL INDUSTRY CAN SOLVE OWN PROBLEMS

It would be an exaggeration no doubt to attribute the widespread public concern over the future of America's oil supply solely to the circumstance that the northeastern United States has just experienced the worst winter in twenty years or more. Yet it certainly is true that the narrowly averted shortage, the warnings to consumers to conserve fuel and the occasional interruptions of traffic that caused some localities to be deprived temporarily of heat, have conspired together to create doubt as to the oil industry's ability to keep pace with the rising demand for its products.

As usual public inconvenience has been promptly reflected in protests from official quarters and in proposals, mostly impractical, for emergency or long-range action to meet the assumed menace. As usual, likewise, the situation has been seized upon by the protagonists of state control of industry to urge more or less rigid regulation of oil by government authority. The Secretary of the Interior has chosen the favorable moment to advocate a federal appropriation of nine billion dollars for the construction of plants to turn out two million barrels daily of synthetic products as a means of supplementing waning petroleum reserves. Other projects suggested have been the importation and storage above or below ground of vast quantities of oil as a reserve against emergencies. Bills have been introduced into Congress providing for the setting up of a federal agency with broad powers to control the production, distribution and use of petroleum and its products. Here and there persons of short vision have raised their voices to advocate a prohibition of the further use of oil as household or industrial fuel and to forbid the building of diesel engines for railway transportation. This suggestion for turning back the hands on the clock of progress has not gained much support thus far, but it shows the extent to which apprehension has risen among those who are ill-informed or whose judgment is ill-balanced.

Members of the petroleum industry have not been oblivious of the change taking place in the demands put upon them, nor have they been neglectful of efforts to meet the broadening expansion of petroleum requirements throughout the fields of industry at large. It is true that they could not anticipate the dizzying rate at which the consumption of certain of their products has mounted in the brief period since the close of the late war. But they recognized that oil would continue as it has for half a century and more to supply a larger and larger proportion of the world's industrial energy, both because of its superior efficiency and because of changes in the mechanism of consumption. They planned on the expenditure of four billion dollars this year and next in increasing production, expanding refining capacity and extending the facilities of transportation. The story of the unavoidable delays in carrying out this program due to lack of materials and other obstacles to construction has been told repeatedly.

Looking at the present picture objectively, it does not appear that the oil industry has made a discouraging showing. Although total demand in the United States had risen to 5,450,000 barrels daily in 1947, supply was able to keep slightly ahead of this figure and to permit a net export of 150,000 barrels daily. During the year the country set a new high record in footage drilled. More than 30,000 wells were drilled and of 5,300 exploratory drillings, 15 percent were oil producers. Despite the highest withdrawals in history, it is estimated that two billion barrels were added to the country's known reserves. Drilling activity in 1948 is expected to increase substantially, but even though results in the way of field discoveries and extensions are no greater than in the twelve months past, it is evident that it will be possible for the domestic industry to satisfy home demands for the immediate future.

Members of the oil industry are well aware, however, that to maintain a reserve of potential production in the face of rapidly expanding consumer demand may present difficulties and that they have a problem requiring serious consideration. The first and easiest recourse is import. A gradual increase in crude imports along with a decline in the export of products is anticipated. At the present time the United States is taking as much foreign oil as is obtainable, but it is expected that with more Middle East oil moving to European markets, daily imports from Mexico and the Caribbean area may reach 550,000 barrels daily.

To meet the needs of the eastern seaboard for home and factory heating, one prominent engineer has recommended the piping of natural gas in large quantities to this area, supplementing this supply if necessary by the gasification of coal. This, he points out, would relieve the draft upon crude supplies for the production of distillate fuel and permit its use for other products. In the meantime work is under way on the construction of two plants that will produce gasoline and other products from natural gas, and one large oil company is spending $10,000,000 in the study of coal gasification and other methods of synthesis. Left to itself it is safe to predict that the oil industry will cope with the problem of rising demand and will do so more economically and with far less waste than it could be done by government.

Recording boat at work in the open Gulf.

OPERATING PROBLEMS OF MARINE SEISMIC SURVEYING

By
R. A. BOULWARE*
and
E. D. ALCOCK*

IN any type of marine exploration costs are going to be extremely high per unit of time; however, if the operational problems are successfully met, the acreage costs of exploration will be considerably less than that for land surveys. This paper will deal with some of these operational problems and present solutions for them which, although they often result in higher monthly costs, do reduce the acreage cost.

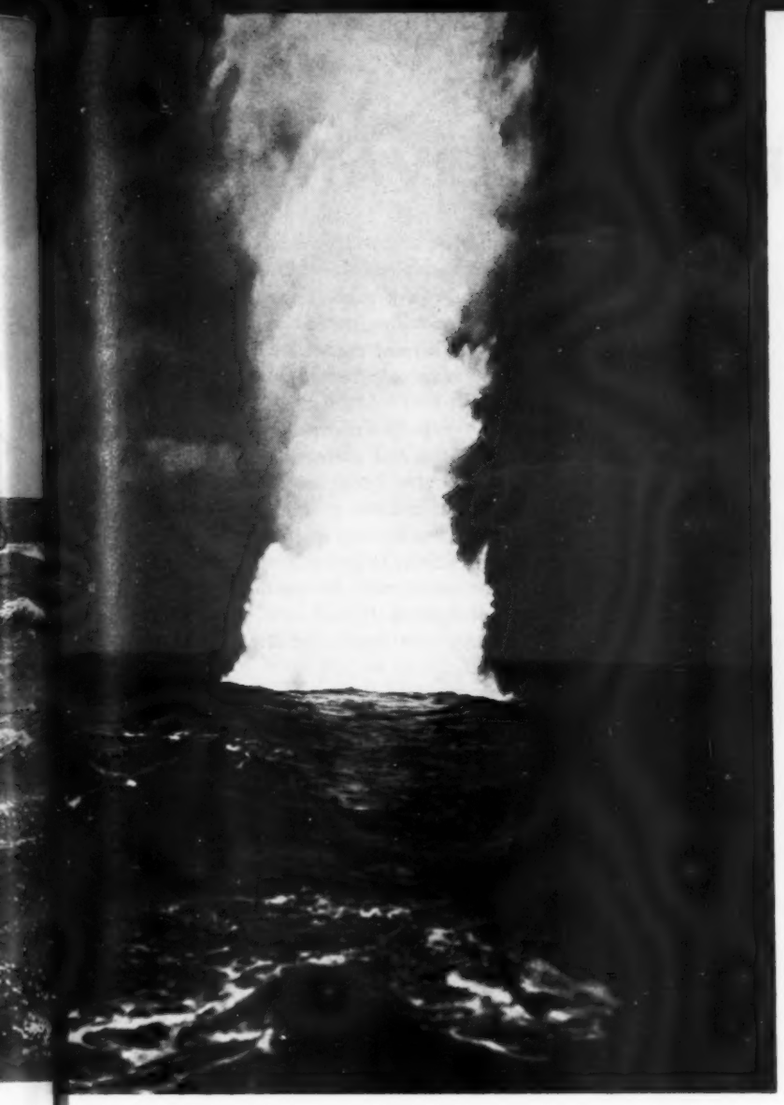
The most severe problem encountered in any marine work is that of weather. While there is no perfect solution to this problem, there are several things which can be done to minimize its effect on production. It has been the normal practice in the past to operate the survey on a ten-work-day, four-rest-day schedule. It has proved to be advantageous to abandon this type of work schedule for one which calls for work every day during the month, thus allowing full advantage to be taken of every suitable working day. To operate this type of work schedule, it is necessary to maintain approximately one and a half times the personnel required for normal operation. It is also necessary that for every job on the crew, there be available at least two men capable of performing it. In this manner it is possible, by staggering the individual work schedules, to give each man his earned rest time and still maintain full-time operations when weather permits throughout the month. This increased personnel increases the monthly costs, but experience has shown that the increased production more than offsets this cost increase, and as a result the per unit cost is lowered.

Another important factor in minimizing the effect of weather is the boat equipment. Experience has shown that larger and more seaworthy boats amply repay their increased cost by allowing the survey to proceed in rougher seas than is possible with small boats. It has been found that converted naval craft eighty-five feet in length or longer make excellent recording boats and deep-sea fishing craft sixty feet in length or longer complete the boat complement. All of these boats have intercraft radio communication and radar equipment which aids the work during foggy weather. In addition the recording boat is equipped with ship to shore telephone service for immediate communication with the shore base. One of the important operational problems in connection with the boat equipment is the necessity of going for long periods of continuous operation without breakdowns. All boats are subject to a certain amount of breakdown trouble. To minimize the lost time due to boat breakdowns one should select boats in the best possible condition, make all minor repairs when the need arises, and when major repairs are necessary, fly repair parts and mechanics out to the boats.

A second operational problem is that of surveying. Since in some types of seismic work measured distances are used in calculating the results and since these results are presented in map form, it is necessary that we be able to locate ourselves with accuracy at all times. In this respect we are fortunate in having two wartime developments of the armed services, radar and shoran. Neither of these two developments presents a final solution to the problem, but both of them are far superior to any method which has been available to us in the past. Both shoran and radar are being used by various companies doing marine exploration, and while both have shortcomings at present, these no doubt will be overcome by future developments. The main shortcomings of both methods are the necessity of highly skilled operators and their inability to operate continuously over long periods of time without repair, both of which might be overcome by improved instrument design and construction.

A third operational problem is that of designing and using instruments and techniques to utilize the available work time efficiently. In regard to speed of operation marine work has several inherent advantages over land work, and by properly utilizing these advantages to the greatest degree an increase in production will result. One of the greatest advantages is that no holes are required for the explosion of the shots, since dynamite exploded under water is a very efficient

* National Geophysical Company, Inc.



Preparing to launch a dynamite charge from a shooting boat. †

← An underwater seismic explosion.

source of seismic energy. A second advantage is the ease with which the equipment can be moved from one point to another.

There are, of course, some disadvantages inherent in marine work, and if one tries to utilize the instruments and techniques which have been designed for land work, one is seriously handicapped. One disadvantage is that one cannot walk on water; therefore, the conventional land procedure of setting out and picking up the seismometers had to be revised and was the subject of a great deal of research and experimentation by the various geophysical companies. One general solution is to build a single cable, with the conductors built around a strong strain wire, with the seismometers built into the cable, and then cover it with a waterproof covering. Experience has shown the advantage of building such a cable in sections, each section containing one seismometer. With such a cable repairs can be made easily and rapidly by replacing the defective section. These cables are then reeled out at the start of the day's operation and towed or dragged from one location to another during the day. The seismometers which are in general use in the industry demand that they be in an approximately vertical position. This is accomplished by mounting the instrument in gimbals within the waterproof case so that under the influence of gravity, the instrument will assume a vertical position regardless of the cable.

Due to the weight of such a cable, it is handled by a large diameter motor-driven cable reel mounted on the rear of the recording boat. When the cable is laid out or reeled in, it passes over a small wheel mounted out from the rear of the boat to prevent its becoming fouled in the propellers. Since this cable is dragged on the ocean bottom, it is subject to considerable abrasion from sand, shells, etc., and yet it must remain waterproof in order to carry the small electrical currents from the seismometer. Overcoming as it does the disadvantage of handling instruments under water, this type of cable enables us readily to move from place to place on the water and, therefore, more than justifies the cost of its development and maintenance by increased production.

An important advantage of marine work is that of being able to explode the dynamite in water without the use of holes, but in practice this has presented several difficulties. One problem that arises is the possible damage to marine life by underwater explosions. Experimental tests have been conducted under the supervision of various state agencies to determine actual results which show that when the explosion takes place under proper conditions, the damage is inconsequential. In spite of the wide publicity given these data commercial fishermen are not completely convinced that their means of livelihood is not being hurt by the activities of exploration work, and as a result there is considerable opposition and some interference with the work.

At first the dynamite was exploded on the ocean floor, since this was the easiest manner of placing the charge. It was found, however, that when dynamite is exploded under several feet of water, extraneous energy is generated which obscures and interferes with the seismic results. Upon experimentation it was found that this energy results from the oscillation of the gas bubble in the water and can be overcome by the use of excessively large charges or by floating the charge of dynamite only a few feet under the surface of the water. The latter solution to the problem has been generally adopted, since the former is costly, dangerous and causes excessive damage both to marine life and to the ocean floor.

Another problem in marine work arises from the great distance from a shore base at which the work is conducted and the low speed of marine transportation. In general it is not practical for the crew to return to shore base each night; therefore, living accommodations must be provided on the boats for the working personnel. The expenditure of considerable money and time in improving the living conditions of the personnel on the boats is amply justified by improved morale and the resultant increase in production.

The total monthly cost of a marine seismic crew will be three to four times that of a normal land crew; however, if the proper equipment, techniques and personnel are used, the production should be five to seven times that of the normal land crew. It is, therefore, apparent that the additional cost of properly equipping and maintaining a marine crew will reduce the overall cost of the entire marine exploration program.

GAS-OIL RATIO FACTOR IN CONSERVATION*

By ERNEST O. THOMPSON

Chairman, Texas Railroad Commission

Ernest O. Thompson

THERE are, as of this date, 187 counties in the State of Texas which produce oil or gas in substantial quantities. These counties include 1,250 oil fields and approximately 831 gas fields. Also included are 1,724 gas reservoirs. As of February 7, 1948, there were 106,660 oil wells and 8,623 gas wells in the state. As far as regulation and conservation is concerned, each field and reservoir requires its own special treatment from the standpoint of regulation and operation. The subject of conservation in Texas, therefore, is both complex and diverse.

All conservation regulations, whether in Texas or in any other state, are properly designed to prevent waste. As a result of this concept their real meaning and significance is likely to be overlooked. What actually happens is that by conserving the natural energy of a reservoir, we obtain a greater ultimate recovery and the use of a greater volume of the resources which we have already discovered, and we increase the real wealth and productivity of the country just as surely as if additional money and effort were put forth to secure an equivalent amount of entirely new reserves. Conservation, then, has created a distinctly new source of supply of oil and gas. One of the best examples of a conservation measure contributing to this new supply is the program of efficient gas-oil ratios. In Texas we have vigorously applied this principle of using the most efficient gas-oil ratios.

Of the 106,660 producing oil wells in Texas, more than 50 percent are connected to gasoline plants. Nearly two billion cubic feet of casinghead gas is processed daily, and 190 gasoline extraction plants are operating in the state. Texas has become the foremost producer of natural gasoline in the nation. Cashinghead gas is, therefore, an important resource in itself, but as an agent for moving oil through the sand and carrying it to the surface, it is even more valuable.

The source of energy by which oil is produced is of special importance in every oil field. Oil movement through a sand is caused by a pressure differential existing between the well bore and the communicating parts of the pay formation in the reservoir. This pressure differential between the various parts of the reservoir and the well bore may result from one of the following three sources or from all of them: (1) gravitational force, (2) the force of water drive, (3) the force of expanding gas. In dealing with gas-oil ratios, the third force, the force of expanding gas, is of great importance, for this force is either in solution or in contact with oil. The energy content of gas, as measured by the gas pressure, is one of the principal causes of oil movement through sand. The vital and fundamental part which gas energy plays in its propulsive function in driving oil within the reservoir toward the well bore and thus enabling it to be recovered, saved and produced, is so well establtablished that it is no longer questionable from an engineering standpoint.

The Legislature of Texas took cognizance of this factor in enacting laws requiring the Railroad Commission of Texas to establish an efficient gas-oil ratio for each of the oil fields in the state. In the recent case of Shell Oil Company vs. the Commission (December, 1947,) the Supreme Court (final court) said that each field presented a separate study and a distinct problem. This was a far-reaching decision in which the court held for the first time that the Commission had the power and the duty to prevent the flaring of gas from oil wells wherever it was economically and reasonably possible to do so.

As of April 1, 1947, the Commission had ordered the operators in the Seeligson field to cease the flaring of some 38 million cubic feet of gas daily which was produced with the oil. The operators enjoined the order, and the Commission appealed directly to the Supreme Court with the above-mentioned result. The operators contended that the Commission had no authority to stop flaring where a 2,000 to one gas-oil ratio was permitted in the order.

These laws define waste as being, among other things, "the operation of any oil well or wells with inefficient gas-oil ratio." In the absence of an active water drive, when the gas pressure in a sand has decreased to approximately atmospheric pressure, there is little differential pressure between the sand and the well bore, and production ceases, even though from 50 to 75 percent of the oil content may remain in the reservoir, never to be recovered by ordinary methods. Hence, where gas is permitted to escape without doing useful work, underground waste will result. An efficient gas-oil ratio will tend to conserve this source of energy by bringing the oil to the bore of the well where it may be recovered in greater amounts.

A great deal of excellent work has been done on gas-oil ratios and their effect on oil recovery. However, very little has been written about how to put efficient gas-oil ratios in effect. It is not always an easy matter, in adopting rules and regulations, to determine just what the most efficient gas-oil ratio for an oil field should be. It is even more difficult in a great many cases to make this ratio effective after it has been determined.

The Commission early found that the gas-oil ratio limit prescribed for a field is one of the best methods of conserving natural energy. It also found that it is not enough merely to promulgate a rule fixing a maximum permissible ratio; there must be some device for enforcing it. In the early days of promulgation of gas-oil ratios, there were not enough operators, for example, who knew within accurate limits at what ratios their wells produced. The rules of the Commission were far ahead of most operating practice from a reservoir control standpoint.

Gas-oil ratios formerly were measured according to three standards, all of which are only distantly related to Reed's Tables. If a well did not make enough gas to light a cook stove on the lease, it was considered to have a low ratio. If, on the other hand, it was possible to hear the riser screaming for three-quarters of a mile, the well's ratio was apt to be considered inherently high. All wells falling between these two classifications were dismissed as having average ratios.

It was obvious, therefore, that before anything could be done toward conservation from a gas-oil ratio standpoint, facilities and standard procedure must be developed for the actual measurement of gas volumes produced with oil. Accordingly the Commission promulgated an order fixing the procedure for measuring gas volumes used in computing gas-oil ratios. A booklet was published by the Commission in 1939 entitled "Method for Determination of the Volume of Gas Used in Computing Operating Gas-Oil Ratios." This booklet explains in simple layman's language how a gas-oil ratio should be taken, the proper equipment to be used in a particular case, and gives a complete set of tables whereby the correct answer may be read without going into any engineering calculation. It then initiated a policy of requiring rotating statewide ratio surveys, which insured a test of every well at least once a year. In areas where a chronic gas-oil ratio problem exists, these surveys are made much more often. In some fields tests are made once each month, and in others they are taken each three months, et cetera, according to the producing characteristics of each particular district.

* This paper contains the latest statistics on the progress of gas-oil ratio regulation as compiled by the staff of the Texas Railroad Commission.

With this information available the Commission was able to install an effective gas-oil ratio program through the state of Texas. The Commission through its district offices aided the operators in conducting these gas-oil ratio surveys by sending out the Commission's own engineers to the various fields to assist wherever necessary. During the war and the shortage of help, the Commission adopted a system of spot-checking in determining whether changing conditions or inaccurate tests had resulted in the use of erroneous ratio values. This system used by the Commission has improved the gas-oil ratios in most fields and has induced the operator of high gas-oil ratio wells to correct them and to bring the wells in question within the limiting gas-oil ratio set for the fields. The gas-oil ratio rule for a field has been enforced primarily by the simple expedient of setting a gas limit for each well and reducing its oil allowable, if the well has a ratio above that set for the field, to a point where it is allowed to produce no more gas than if its ratio were normal.

From the time of the original legislation on gas-oil ratios in 1933 to the present, the Commission, after due notice and hearing, has established a statewide gas-oil ratio of 2,000 to one; and in a number of fields it has instituted ratios as low as 500 cubic feet per barrel of oil. At the same time to increase the ultimate recovery of oil from gas cap reservoirs in which gas wells are completed, the Commission has adopted Rule 6 (a) and 6 (b) which read as follows.

6 (a) "Any oil well producing with a gas-oil ratio in excess of two thousand (2,000) cubic feet of gas per barrel of oil produced shall be allowed to produce daily only that volume of gas obtained by multiplying its daily oil allowable, as determined by the allocation formula applicable to that well by two thousand (2,000) cubic feet. The gas volume thus obtained shall be known as the daily gas limit of such well. The daily oil allowable of such well shall then be determined by dividing its daily gas limit, obtained as herein provided, by its producing gas-oil ratio in cubic feet per barrel of oil produced.

6 (b) "Any gas well producing from the same reservoir in which oil wells are completed and producing shall be allowed to produce daily only that amount of gas which is the volumetric equivalent in reservoir displacement of the gas and oil produced from that oil well in the field which withdraws the maximum amount of gas in the production of its daily oil allowable. By the maximum amount of gas is meant that number of cubic feet of gas equivalent to the product of the daily oil allowable for such well as calculated by the allocation formula for the field, multiplied by two thousand (2,000) plus a volume of gas in the reservoir equivalent to the daily volumetric oil withdrawal from such oil well. In converting the daily oil allowable from such oil well to its volumetric gas equivalent in reservoir displacement, the average reservoir pressure and the average reservoir temperature of the field in question shall be used. Provided, however, that where gas produced from an oil reservoir in a field is returned to the same reservoir from which it was produced, only the volume of gas not returned to the reservoir shall be considered in applying the above rule."

The Railroad Commission of Texas for a period of years has taken vigorous steps to reduce the waste of casinghead gas to a minimum. Besides fixing a gas-oil ratio limit for the field, it has recently taken steps to reduce gas-oil ratios in fields where practicable to solution ratios. An example of such constructive work is illustrated by the latest order written by the Commission for the Stratton field, located in Nueces County, Texas. Another field for which the Commission instituted a solution ratio is the Old Ocean field, in Brazoria County, Texas. After notice and hearing the Commission found that the greatest ultimate recovery of oil from the various reservoirs in both of these fields could only be obtained by maintaining pressure in the gas caps, and that all of the casinghead gas should be returned to the crest of the gas caps in order to maintain the pressure; to accomplish this, gas-oil ratios must be controlled and oil produced from these reservoirs with minimum gas-oil ratios. The Commission further found, from the evidence adduced at various hearings, that the mechanism of a gas cap drive involves displacement of the oil by free gas from the gas cap, and that this drive is capable of yielding high oil recoveries efficiently if properly controlled; and that in a gas cap drive field the oil level in a reservoir falls as production proceeds; and to maintain reservoir energy produced from the gas cap, the Commission instituted in the Stratton field a solution gas-oil ratio of 785 cubic feet of gas per barrel of oil. In the Old Ocean field it fixed a solution gas-oil ratio of 650 in one sand and 625 in another sand.

Another far-reaching and drastic conservation step inaugurated by the Railroad Commission of Texas was the policy of stopping the flaring of gas from oil wells wherever practicable. Begining in the spring in 1945, the Commission held numerous hearings on all districts in the state in order to learn the facts concerning casinghead gas problems existing throughout the state. As a result of such hearings various projects to conserve this casinghead gas were started by the oil and gas industry in the state. Hearings were again held in the early part of 1946 to determine what steps were being taken by operators to remedy the wastage of gas from oil wells. As a result of such hearings and orders sent out by the Commission for the operators to appear and show cause why certain fields should not be closed in until the operators had utilized the casinghead gas for legal purposes or put it back into the horizon from which it was produced, the Commission, on March 17, 1947, issued an order restricting the production of gas from oil and gas wells in the various reservoirs of the Selligson field, Jim Wells and Kleberg Counties, Texas. As soon as this order was issued by the Commission, it was attacked by the operators. The district court then granted the operators a temporary injunction, restraining the Commission from enforcing this order. The Attorney General appealed this case, and the Supreme Court on November 26, 1947, handed down its decision which declared that the Commission had the statutory power and authority to shut in any field where casinghead gas is being flared to the atmosphere if it is found that it is feasible and economical to pick up the casinghead gas and put it into a line for beneficial uses. The industry as a whole, as a result of the Commission's hearings and its firm stand on enforcing gas-oil ratio limits in the field, has made record strides in the conservation of casinghead gas. The story of the progress made by the operators and producers of casinghead gas may be told as follows:

On November 1, 1946, there were nine completed projects utilizing 52,000,000 cubic feet of casinghead gas daily, 16 projects under construction which would utilize 221,000,000 cubic feet of castinghead gas daily, and 44 projects in the planning stage which would eventually utilize 485,000,000 cubic feet of castinghead gas daily. The total cost of this construction will amount to $127,000,000. As of April 10, 1947, a survey reflected that at that time 15 projects had been completed and were saving 101,000,000 cubic feet of gas daily that had been previously vented to the atmosphere. Ten plants were under construction which would process 174,000,000 cubic feet of castinghead gas daily, while 44 plants still in the planning stage would ultimately conserve 485,000,000 cubic feet daily. The latest statistics compiled by the Commission show that as of November 1, 1947, 23 propects have been completed utilizing 260,000,000 cubic feet of castinghead gas daily with 15 plants under construction, most of which will be completed during the spring of 1948 for a saving of 272,000,000 cubic feet of casinghead gas, leaving 35 projects still in the planning stage which will pick up 322,000,000 cubic feet daily of casinghead gas now being vented.

It is hoped that, when this immense conservation program has been completed, the amount of casinghead gas vented in the state of Texas will be reduced to 18.4 percent of the total produced. The following table will show what strides have been made in this important program since its installation up to the present report:

Date	Percent Casinghead Gas Flared
March, 1945	57.3
August, 1946	43.2
January, 1947	40.5
April, 1947	39.5
Upon completion of all projects	18.4

It is also well to point out at this time that the utilization of casinghead gas in the state of Texas will get into full stride during 1948 upon the completion of the Texas-California Pipeline now under construction by the El Paso Natural Gas Company. When this project is completed, most of the casinghead gas being flared in District 8 will be saved, compressed and put into the pipeline to be used for light and fuel purposes.

OKLAHOMA'S FIRST COMPULSORY UNIT AT WEST EDMOND

By MILLARD K. NEPTUNE
Assistant Manager, West Edmond Hunton Lime Unit

AS IS true with most technological advances, the credit for unitizing must be distributed among many persons. But in the late 1920's and early 1930's one man stood out as the leading advocate of unit operation of reservoirs. That man was Henry L. Doherty, founder of the great Cities Service enterprises. Mr. Doherty walked out of the American Petroleum Institute because its board directors refused to put its stamp of approval on this "new concept of production," as it was referred to in many papers read in that period before the API and the Petroleum Division of the American Institute of Mining and Metallurgical Engineers. In his zeal Mr. Doherty even threatened to purchase newspaper space to campaign for compulsory unitization. To an industry which looked upon voluntary unitization as a radical move, the idea of compulsory unitization was most repugnant.

Millard K. Neptune

Today compulsory unitization has been accomplished in two pools in Oklahoma and a third has been ordered unitized, after a half-day hearing at which no opposition was voiced, thus indictating the change in attitude which has occurred since Mr. Doherty's time.

The first compulsory unit to be organized under the terms of Oklahoma's 1945 compulsory unitization law was the West Edmond Hunton Lime unit embracing 29,640 acres lying mostly in Oklahoma County, Oklahoma, but lapping over into Canadian, Kingfisher and Logan Counties. The 317 leases in the field were owned by 146 separate working interest owners and several thousand royalty owners. The field represented a clear example of the futility of voluntary unitization. It would have been hopeless to try to get the 146 working interest owners and the several thousand royalty owners to agree on terms of unitization. Its unitization by compulsion is the most significant single step in the entire history of unitization.

Decisions in early court cases revolving around the nature of the ownership of oil and gas established the ownership as being similar to the ownership of wild animals on a person's land—the ownership was a qualified one and subject to being terminated by the animal hopping the boundary into the land of another. Ownership became fixed only when the animal, or the oil, was reduced to possession. The law of capture became one of the cardinal principles of oil and gas law.

The natural result of the law of capture was the high competition among land owners and their lessees to reduce the oil to possession through wells drilled on their land. It made no difference that the oil, or part of it, had migrated from the land of another. Neither did it matter that in producing the oil the gas energy was vented to the air. It was too early to think of another analogy to wild animals—all owners working together to herd the animals to the spot where the greatest number could be most easily captured with all hunters sharing the take on an equitable basis.

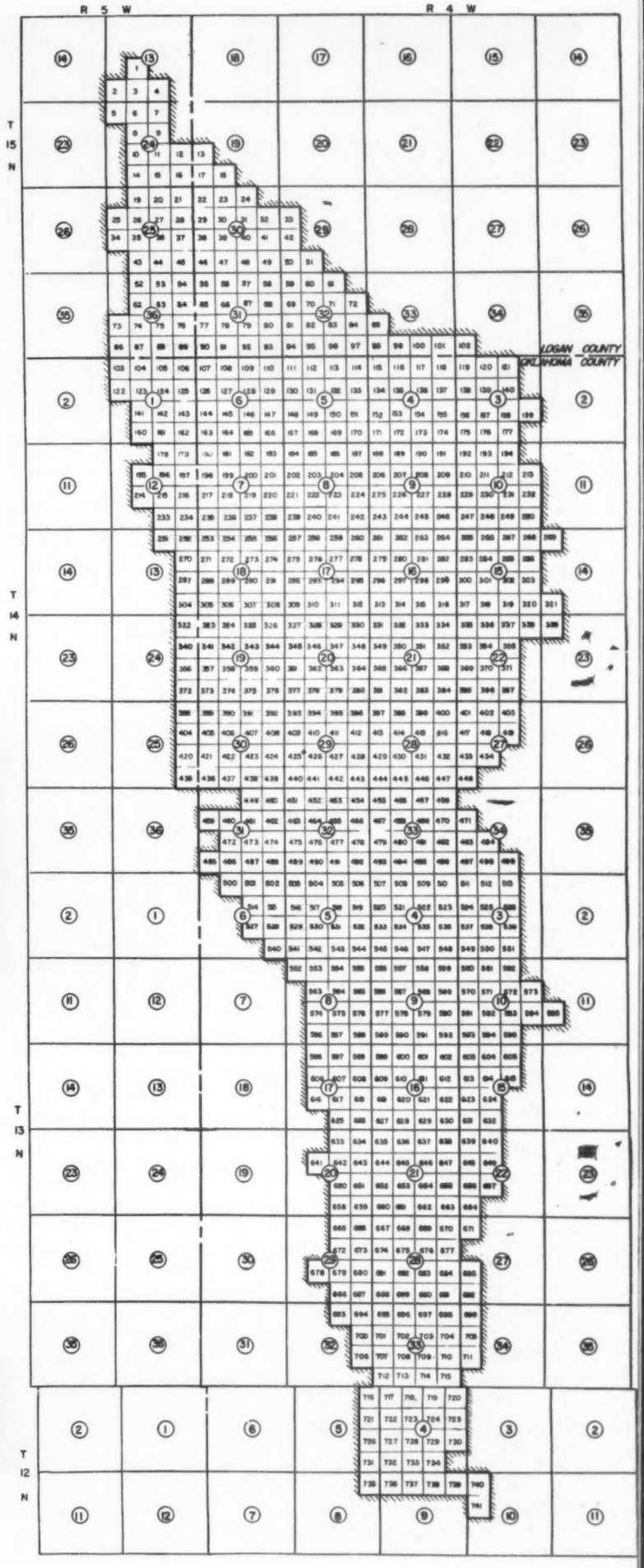
When the idea of the common approach was first considered, there were three obstacles to prevent its fulfillment: (1) lack of knowledge of what happens beneath the ground as an oil field is produced; (2) the rugged individualism of the oil producer who said, "You take care of your leases and I'll take care of mine," and (3) the law of capture which encouraged him to say it.

Time has whittled at the effectiveness of these obstacles. The science of petroleum engineering,, though still growing, no longer permits ignorance of what goes on in the reservoir. The enlightened self-interest of the land-owner and his lessee has reduced the ranks of "rugged individualist" opponents to unitization to a minority of recalcitrants. Now, Oklahoma, following earlier cases which have qualified the law of capture, slices again at the unfortunate principle and provides for compulsory unitization.

The new law does not permit compulsory unitization in fields which, at the time of its enactment, were being subjected to some sort of secondary recovery; moreover, an order of compulsory unitization will be set aside if fifteen percent of the owners file objections within sixty days of issuance of the order. But these limitations will not prevent compulsory unitization in the newer and more important fields. There now exists a procedure by which intelligent operators, with a willingness to be reasonable, can organize a common rabbit-hunt, in accordance with the best petroleum engineering principles. There is room for argument as to the degree of benefit to be gained from the unitized development and operation of an oil field, but there can be no question that there is a substantial benefit.. Increases in ultimate recovery will vary from a few percent to 100 percent in some instances.

The concept of compulsory unitization which was

Terrain in the West Edmond field is generally level, being devoted largely to grazing and farming. Photo by Corsini for Standard Oil Co. (N.J.)



Right: Map of the 30,000-acre unit.

H. N. Pardee, manager of unit operations.

Earl D. Wallace, chairman of the West Edmond Operators Committee.

Weston Payne, vice chairman of the West Edmond Operators Committee.

so abhorrent in 1930 is now an established institution in Oklahoma. To this extent at least, the engineers have been unshackled from the law of capture by the same state which pioneered oil and conservation and well spacing laws and whose governor was the instigator and first chairman of the Interstate Oil Compact Commission.

Initial consideration of a compulsory unitization law was started before the West Edmond field was discovered, but by the time it had been enacted by the legislature and signed into law by Oklahoma's oil man Governor Robert S. Kerr on April 19, 1945, the West Edmond field had been found and there were approximately 500 wells producing. While there was much skepticism as to the possibility of successfully applying the law to the West Edmond field, both the law and the field were young when first consideration was given to the project.

A field engineering association had been formed early in the life of the pool, and when the law was finally passed, a factual picture of the field was substantially complete. Had this work not been done, or had the law been delayed until the next session of the legislature, the opportunity for maximum benefits of unitization would have passed, no effort to unitize would have been made, and another great oil field would have seen its energy wastefully dissipated.

The West Edmond field was discovered as a result of a typical promotion deal of the type which is responsible for so many oil field discoveries. Ace Gutowsky, who had promoted many plays in Oklahoma, assembled a small block in the vicinity of Section 32, Township 14 North, Range 4 West, Oklahoma County. The venture capital came from several sources, none of which were primarily oil interests. Credit for the discovery does not go to surface geology work, seismograph work, gravity and magnetometer work, or even to the "doodle bug" as is generally alleged, but the credit belongs directly to the lure which the federal income tax laws purposefully and wisely extend to venture capital in petroleum and mining activities.

The first well was started on January 2, 1943, on a ten-acre location in the NW NW SW of Section 32. It was dry in the Wilcox sand and was plugged back to the Hunton Limestone. In this formation the initial test was 535 barrels of oil in 24 hours on a 9/32" choke. Oil field drilling at the time was being regulated as to spacing by the Petroleum Administration for War, and drilling was limited to one well to 40 acres. Subsequent development in the field found the wells being located in the center of 40-acre tracts. Although slow in starting, the drilling campaign which followed was one of the principal development programs in the nation during the late war years and was featured by long step-outs and the consequent hustle to fill in the area proven by the successful step-outs. During the month of February, 1945, sixty-two wells were completed in the field.

The oil-producing horizons are the Bois d'arc and the Henryhouse-Harigan sections of the Hunton Limestone formation and are found at an average depth of approximately 7,000 feet.

The reservoir is a true stratigraphic trap formed as a result of an erosional pinchout against the west flank of the Nemaha Granite Ridge. The productive thickness measured in the wells varies from 12 feet to 193 feet with an average of 61 feet. Measured permeabilities are from 0 to 550 millidarcys and productive indices lead to the conclusion that the effective permeability lies between 10 and 20 millidarcys. The porosity ranges from 0.1 percent to 28 percent and averages 6.5 percent.

The reservoir pressure at discovery was 3,130 pounds per square inch and had dropped to an arithmetic average of 1,709 pounds per square inch on the last survey made prior to unitization. Pressures on this servey varied from as low as 500 PSI to over 2,800 PSI.

From early in the life of the field the desirability for unitization was apparent to many operators and efforts to unitize were begun. Shortly after enactment of the law an operators' committee was formed and within that a steering committee.

The field engineering association, meanwhile, continued its fact-gathering function. A year and a half after formation of the opertors' committee and after many meetings, a plan of unitization was written which was satisfactory to well over 50 percent of the owners and was not apt to be actively resisted by as many as 15 percent. Not the least of the difficulties lay in the fact that there were two gasoline plants in the field owned by only three of the oil operators. The unitization would be a great benefit to the plants by cutting down gas waste and thus adding to the reserves behind the plants. Naturally, there arose the question of who should share the benefit. A formula was finally designed which would give all operators a portion of the benefit by letting them share in the liquids recovered.

To distribute the equity in the unit as a whole, it was divided into 40-acre tracts and each separate tract was weighted on two general considerations: current production and future production. One-half the total equity was divided among the tracts in proportion to the then current allowable of each tract (the allowable was limited to 65 barrels per day or the ability to produce within a given gas-oil ratio, whichever was smaller.)

The remaining one-half of the equity was distributed among the tracts in the proportion which the probable future production of each bore to the total probable future production of the entire area included in the unit. Two specific factors were used in this computation—bottomhole pressure and productive formation thickness. The pressure was used because it reflects the stage of depletion and the reservoir energy available to each tract. Thickness of the productive formation was used because, where the areas are all the same, the volume of the productive formation is proportional to the thickness.

All of the factors used in computing the participations were determined by a committee of engineers using methods which have long been accepted in the industry and in financial circles for determining oil property valuations. At the hearing before the Corporation Commission, the

engineers' findings were subjected to hostile scrutiny before the Commission and its experts; however, even the opponents had no fault to find with the work of the engineering committee.

The application was filed on January 29, 1947, and hearings extended into the summer as a result of determined opposition. The Oklahoma Corporation Commission was sympathetic to unitization and anxious to speed up its formation, but it also carefully provided the small percentage of opposition ample time to prepare and present its side. The Commission's order authorizing the creation of the West Edmond Hunton Lime unit was issued on July 29, 1947.

The sixty-day period during which 15 percent of the owners could veto the Commission order expired on September 29. No such protest had been filed; however, a group of royalty owners had appealed the case to the Oklahoma Supreme Court on the grounds of unconstitutionality and also on merit. In spite of the pendency of the appeal, the operators overwhelmingly approved going forward with the unit operation, the effective date to be October 1, two days after expiration of the protest period. They agreed to share the legal risks involved on the same basis by which they held interests in the unit. Thus, four years and five months after discovery of the field, two years and five months after enactment of the compulsory unitization law and more than two years after the organization of the operators' committee, the first compulsory unit came into existence at West Edmond. The operations of 32 companies with 114 non-operating partners in 317 leases became, in effect, one lease with one operator and 145 non-operating partners.

Unlike the voluntary units which had preceded it, the plan of unitization for the West Edmond Hunton Lime unit did not call for an exchange of assignments of lease-hold interests. As to well and lease equipment, however, it was provided that these should be pooled and each partner should own an undivided interest in the whole. With crews loaned to the unit operator by partners in the unit, a physical inventory was taken of all tangible equipment. This equipment, when priced at 75 percent of new value, totaled $11,837,000 and required 2,400 pages to list. Some leases were more completely equipped than the average and their owners received credit for this. Others were incompletely equipped and their owners were charged for the difference. The big adjustment, however, was occasioned by the difference in equities assigned the various tracts. The charge for the total inventory of $11,837,000 was distributed among the operators in proportion to their equity in the unit. If a partner's equity was high in relation to the number of wells contributed to the unit, that partner was required to pay money into the inventory adjustment. If a partner's equity was low in relation to the number of wells contributed to the unit, he received a refund. One company paid $385,000 and another company received a refund of $280,000. The complete inventory was so voluminous that to provide all partners with copies would have resulted in an expenditure of $6,000 for paper alone. It was decided, therefore, that each partner would be furnished with a copy of only that portion of the inventory applicable to the leases in which the partner held an interest prior to unitization. Several copies of the complete inventory are being bound in volumes and will be available through the office of the unit operator on a lending library basis.

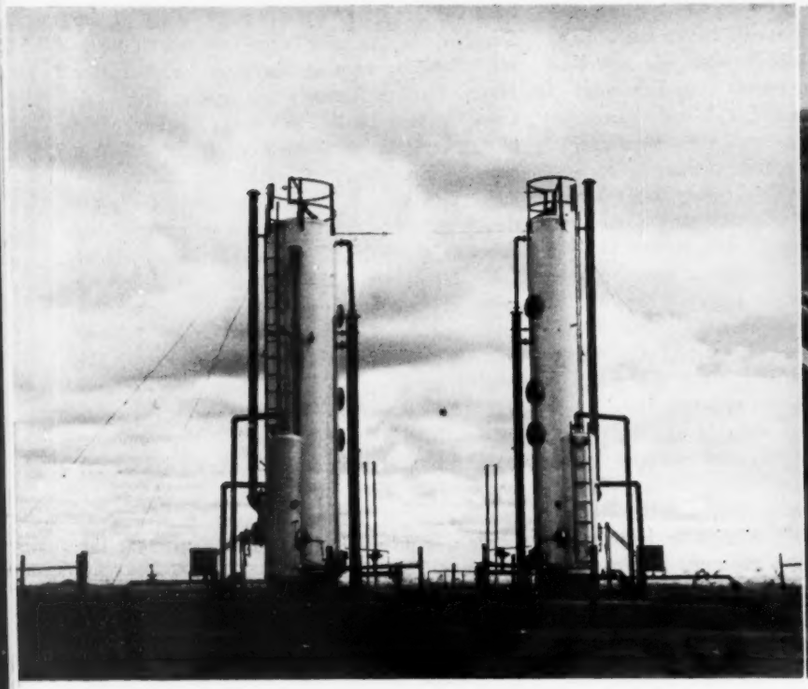
The plan of unitization designated Sohio Petroleum Company, the operating subsidiary of the Standard Oil Company (Ohio) as the unit operator. Sohio in turn appointed as unit manager H. N. Pardee, formerly manager of the Mid-Continent division of The Texas Company. Most of the key positions were filled from the Sohio organization. Pumpers, roustabouts and maintenance men were taken into the Sohio organization from several of the companies contributing leases to the unit. They became employees of Sohio Petroleum Company, and no difference exists in their status from the status of Sohio employees elsewhere in the organization. They were given the benefit for their service with the previous employer in determining their vacation and seniority privileges with Sohio. It is noteworthy that under unit operation the manpower requirements are approximately one-third of the requirements prior to unitization.

There was no particular formality to mark the take-over. Within a few minutes before and after 7:00 A.M. on October 1, all 1,000 tanks in the field were gauged so that proper adjustments could be made for legally produced oil in storage. Several of the former operators left their pumpers and key supervisory personnel in the field for several weeks to assist the unit operator in the take-over operations. By the middle of October, however, the unit organization had matters well in hand.

One of the first administrative problems encountered was in the payment for oil and gas produced. Under the order of the Corporation Commission and the plan of unitization, the proceeds from all oil and gas produced are allotted to the individual 40-acre tracts throughout the field on the basis of the percentages contained in the plan of unitization. The amounts allotted to the tracts are then distributed among the owners of the respective tracts. In order to eliminate the necessity for each purchaser to have division orders and to make payments with respect to each of the 741 separate 40-acre tracts, the unit operator and the four purchasers in the field have made an arrangement whereunder the unit operator determines the total proceeds to be distributed, and each purchaser computes and pays on the tracts on which he had paid prior to

Left: Pumping unit on a Sohio Petroleum Co. West Edmond lease.

General view of field. Corsini photo for Standard Oil Co. (N.J.)



Separators and heater crude treaters on a Stanolind lease.

West Edmond field camp of Stanolind Oil & Gas Co.

unitization and for which the purchaser has division orders. Those purchasers paying out less under this arrangement than the value of the oil actually received during the month send checks for the difference to the unit operator. The unit operator then distributes this money to other purchasers who have received less value in oil than they have paid out. This arrangement is working out very satisfactorily.

The majority of the owners in the West Edmond Hunton Lime unit are in favor of going forward immediately with a full-scale pressure maintenance program; however, in order to secure the support of the unit from those companies which are not convinced of the benefit of pressure maintenance, a compromise was included in the plan of unitization calling for a pilot injection program. Upon the results of this, decision is to be made as to the full-scale program. Material has been ordered for the pilot injection, and the first gas should be injected about March 1, 1948.

During the month preceding unitization the unit operator had taken gas-oil ratio and production tests on all of its own wells, and immediately upon taking over the unit the program of testing was extended to the balance of the field. Within 60 days after the effective date of the unit production tests and gas-oil ratio tests had been completed on all but a few of the wells in the unit. The tests revealed that the gas production was extremely high, considerably above the already high estimates which were being made. Bottom-hole pressure tests were also made on approximately 225 wells through the field, showing an arithmetrical average of 1,376 pounds per square inch, a drop of 3.33 pounds per day since the last previous test taken 7½ months earlier and with an intervening production of 26,700 barrels per pound of pressure drop.

During the first month of unitization the pipeline runs averaged 47,200 barrels per day as opposed to an average of 35,000 barrels per day for the month preceding unitization. This larger quantity of oil was produced with substantially less gas than the lower quantity had required. By shutting in 173 high gas-oil ratio wells producing 3,500 barrels per day and taking offsetting amounts from the low-ratio wells, it was possible to eliminate gas venting to the extent of over 100 million cubic feet per day.

Although Sohio Petroleum Company is the operator of the field, all 145 of the non-operating partners may exercise a voice in its operation by participating in the meetings of the operating committee which consists of one representative from each working interest owner. The plan of unitization provides for the operating committee and authorizes it to select the unit operator, to determine the nature and extent of remedial operations, to pass upon all expenditures, to determine the rate in which the field should be produced, and in general to direct the unit operator in all details of the operation of the field.

To keep in close touch with the unit operator and to render decisions on matters which arise between the operating committee meetings, an executive committee has been created by the operating committee. Earl D. Wallace, vice president of Standard Oil Company (Ohio) and president of Sohio Petroleum Company, is chairman of the executive committee, and Weston Payne, vice president of Anderson-Prichard Oil Corporation, is vice chairman. These men hold the same positions in the operating committee. Other members of the executive committee are H. H. Kaveler, Phillips Petroleum Company; W. E. Stegmeir, Fox and Fox; E. L. Downing, Magnolia Petroleum Company; W. H. Atkinson, independent operator; C. C. Peppers, president of Peppers Refining Company. Alternates on the executive committee are R. W. French, Sohio Petroleum Company; C. A. Daniels, Phillips Petroleum Company; A. H. Proctor, Magnolia Petroleum Company; T. Murray Robinson, Peppers Refining Company, and George Folk, Anderson Prichard Oil Corporation.

There are also a number of advisory sub-committees. The regular sub-committees and their chairmen are as follows: legal, R. M. Williams, Phillips Petroleum Company; engineering, L. F. Elkins, Sohio Petroleum Company; auditing, J. D. Sunkel, Magnolia Petroleum Company; plant, H. R. Legatski, Phillips Petroleum Company; taxes-insurance-claims, R. E. Leverich, Anderson Prichard Oil Company.

It is no secret that the benefit of unit operation would be more evident and more effective in a pool with a sand formation, but in spite of its being a limestone formation, the West Edmond Hunton Lime unit has the opportunity to demonstrate the advantages of unit operation over competitive operations. Because of its size and because it is the first compulsory unit, it will be watched more closely than the West Cement unit or the Antioch unit, two smaller compulsory units which have been authorized by the Oklahoma Corporation Commission since the West Edmond unit was authorized. The hostile scrutiny will particularly train its guns on the West Edmond Hunton Lime unit. There can be and will be alibis. Here the engineers' hands are at last untied and they must demonstrate what they can do.

SELF PROPELLED CEMENTING EQUIPMENT FOR MARINE DRILLING OPERATIONS

By WM. D. OWSLEY*
and JOE M. JOHNSON**

WITH rapid expansion of the oil industry in all phases, new sources of petroleum have become extremely important. Exploration activities over the past decade have led an unending search for discovery of new fields which have introduced greater depths and higher pressures, thus demanding improved design of drilling and service equipment.

Gulf Coast oil producing areas for several years have been a proving ground for new techniques and practices, for this area presents a bulwark of resistance to even the most modern equipment available today. Great depths, treacherous formations and extreme pressures constitute a supreme test within themselves, but in this area there are other natural environments with which to reckon. The Louisiana coast, with its shallow bays, lakes, lagoons, and canals, is an important oil province. Most of the tidal bodies of water are closed to the Gulf by bars or marshy plains but are connected with it through narrow inlets (passes) or by long and short natural tidal channels. Farther inland vegetation changes from swamp grass to waterlogged jungle. Below these hundreds of square miles of mosquito-infested lowland exist oil and gas formations which extend out into the Gulf itself along the Continental Shelf.

Marine drilling operations have been developed, and today this vast territory is dominated by extensive research in deep well drilling, directly affecting the methods and equipment used in cementing wells in this area. To meet these developments, a new fleet of oil-well servicing boats have been launched. The boat service supplements the conventional practice of transporting land-based cementing units to offshore locations on tow barges. Its development marks the first adaptation to marine operations of handling cement in bulk instead of sacks. Heretofore, the problem of carrying additional equipment on tow barges has prevented utilization of bulk cement advantages at offshore locations.

The unique boat installation provides safer, more convenient handling of equipment as well as more adequate facilities.

Construction of these craft began in November, 1946, near Harvey, Louisiana, across the Mississippi River from New Orleans.

Converted from LCTs, seagoing vessels employed during the war to put tanks ashore, the boats are the first self-propelled craft ever to be outfitted with oil well cementing equipment. Their overall length is 112 feet, beam 32 feet, average draft 3½ feet, making them navigable in nearly all of the numerous waterways traversing the coastal region. Any channel dredged to accommodate a drilling barge will also admit these service craft. The converted LTCs are driven by three screw propellers, each of which is powered by a 165 hp Gray marine diesel engine, a marine conversion of the General Motors 6-71.

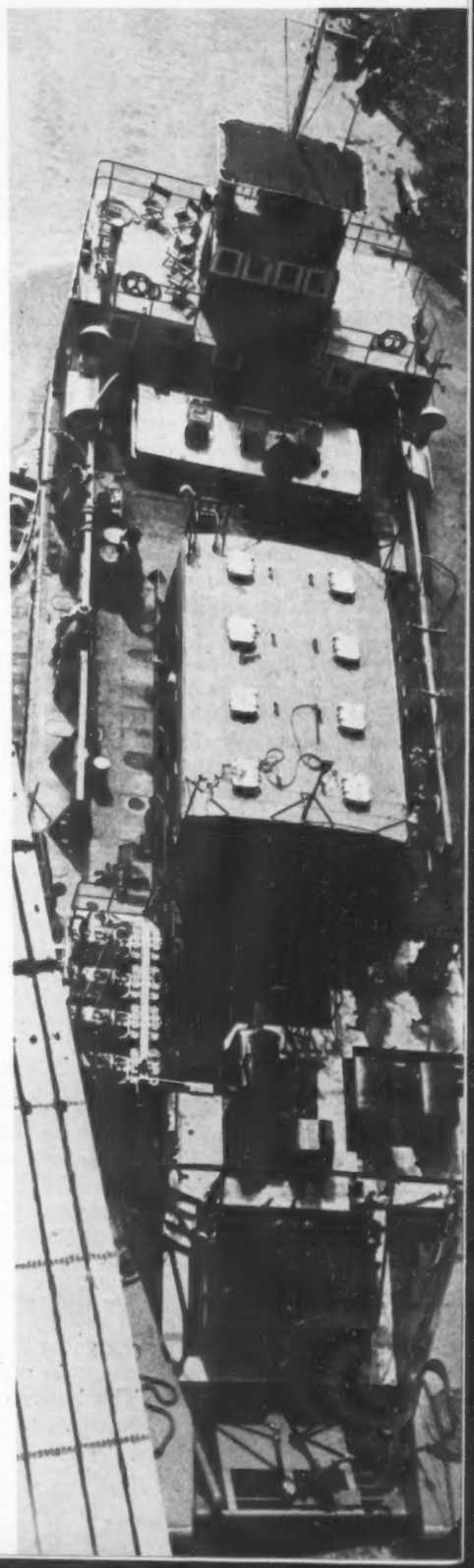
Equipped with both steam and diesel-driven pumps, all permanently mounted, these boats are the equivalent in power of more than three of the standard pump truck cementing units.

Topside installations include pump assemblies and measuring tanks on the bow, bulk cement bins amidships, pilot house and engine control room aft. Below the pilot house are the crew's quarters and directly below are modern kitchens and food storage lockers. A general overall view of equipment installations is shown at the right.

Mounted on the port side of the bow are two power driven cementing pumps capable of delivering in parallel ten barrels of fluid per minute through an open line at zero pounds per square inch.

Recordings have been taken in actual field operations of 64 gallons per minute at 5000 psi. The initial pumps, placed in the field for the first time in 1937, were designed to operate at 6000 psi, but the improved versions now attain pressures up to 8800 psi.

Each pump is driven by a General Motors 4-71 diesel engine equipped with 70 mm injectors to deliver 123 hp at 1800 revolutions per minute. Power is transmitted into the pump gear shaft through a torque converter and a five-speed



Cement boat from derrick monkey board. Cementing pumps and mixing equipment are forward. Amidships are eight 250-sack bulk cement storage bins. →

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** Engineer, Halliburton Oil Well Cementing Co.

Typical drilling location in the Louisiana swamps with dredged revetment for rig.

transmission. The torque converter is so arranged that power can be transmitted either by tydraulic torque conversion drive or by direct engine drive, which aids in tapping maximum horsepower at any desired pressure. A cushion within itself, the torque converter eliminates shock load and supplies smoother, safer operation with longer life efficiency. These power pumps may be compounded where long periods of pumping demand abnormally high pressures, or they may function singly or in parallel through a common discharge line.

A horizontal, duplex, power-driven pump is located near the center and forward on the bow and just ahead of a 40-barrel measuring tank. A power pump capable of attaining pressures up to 4000 psi, its primary purpose for marine service is to supply water to the hydraulic mixer. The unit is designed for compactness and interchangeability on land-operated installations and is powered by the same type engine as that used on the vertical power pumps. Power is transmitted through a four-speed transmission and a right-angle drive. This pumping unit is the work horse of the fleet. Aside from routine mixing duties, it supplies water pressure for washing down and cleaning the entire craft after each job is completed.

Manifolding for the mixer pump is so arranged that water may be drawn from the bayou and displaced into the measuring tank or into the mixer, but ordinarily during cement mixing operations, water is drawn exclusively from the measuring tank. In this manner a double check can be made on the quantity of bulk cement being consumed.

On the starboard side of the bow are four 12 x 4 x 12 steam pumps, used in connection with steam operated drilling rigs. This battery of pumps is capable of mixing and pumping cement slurry into a well at a rate in excess of 40 sacks per minute. With two of the pumps running in parallel, the unit can handle fluid at the rate of 480 barrels per hour. The four can be compounded in line to operate above 9000 psi with 300 psi steam pressure. The entire manifold is so arranged for utmost flexibility to meet both normal and abnormal service conditions. Pumps may be operated individually, in parallel, or in compound as may be required.

Delivery of cement to the hopper during mixing operations is completely mechanical, screw conveyors being employed to feed the mixing bowl from the two V-bottom bins installed in the middle of the boat. Release of the cement into the conveyor channels is controlled by hydraulically operated baffles in each of the eight 250-sack compartments. The baffle mechanism holds cement off the screws until ready for use and thus keeps it from packing in the conveyor tubes.

Directly aft of the measuring tank lies a centrally located remote control station. Mounted on a walkway covering a network of manifolding, this station, a nucleus about which all operations revolve, commands fingertip control of all units. The control panel proper contains engine temperature and oil pressure gages, torque converter temperature and oil pressure gages and tachometers. Here also are the clutch controls, throttle levers and start and stop buttons. All throttles and clutches are hydraulically controlled. Engine governor start and stop devices are electrically actuated by solenoids. The only direct mechanically connected controls are the transmission gear shifts. All valves on tank manifolds are conveniently arranged for speedy manipulation. Mixing operations are centered directly in front and below the remote station for clear vision by the operator. From this point he can direct all activities which include the cement storage baffle positions, rate of flow of cement from conveyors, slurry weight, pump speeds, fluid measurement, applied pressures and rig floor observations.

Other equipment on deck includes a large vise and bench for repair work, lubricant storage, converter fluid storage and davits for lowering and lifting from the side a 12-foot, aluminum run-about boat, equipped with 3½ hp outboard motor. Storage compartments forward on port and starboard sides contain spare parts, cementing plugs, tools and miscellaneous pipe fittings.

Simplified manifolding throughout this project has been the keynote for quick processing on any type of job. Discharge lines from either the steam pump or power-driven pump stations are channeled into a single three-inch discharge line. This line is mounted in boom fashion on the extreme bow point with the anchored end coupled to pump stations through flexible knuckle joints which facilitates a pivoting action from port to starboard, depending on rig accessibility. A winch assembly lifts the three-inch joint to the rig floor level where it is secured for service connection to squeeze manifolding or a casing head quick change as may be required.

This highly mechanized boat is the answer to years of planning by cementing crews and oil field operators. History records the service crews' battle against the elements. A slogan originated, encouraging the oil operators with its challenging determination to "Get there somehow." So today they do "get there somehow," but it is only the skipper's routine assignment. The cook prepares those three squares a day, and at job time the engineer boasts, "Everything's shipshape!" The cementing crews are standing by—their connections are made and on a signal from the rig floor it's "Man the baffles, throttle the screws. . . ." A successful cementing job is underway on the water.

Offshore operations in open Gulf waters demand still another type of cementing unit. Drilling facilities in that area are paramount in size and proportion to land and intracoastal equipment. Designed to cope with high seas and destructive swells, an auxiliary boat which couples to a derrick floor, "V" door side direct, has been employed on one project observed. This boat contains all essential equipment and supplies for operation exclusive of the draw-works proper.

A survey was made among oil company representatives to study various needs of an anticipated cementing unit. A portable installation was emphasized, suggesting power-driven equipment and stressing compactness and minimum weight but yet incorporating all techniques of a proven cementing system. Overall dimensions are critical due to varying sizes of hatch openings in the

Converted LCT, tank landing craft, first self-propelled vessel to be outfitted for cementing. Pilothouse and crew quarters are aft.

Portside view of craft anchored alongside a rig waiting the "go ahead" signal →

weather decks. In some instances, installations of cementing units would be made on the second floor level amidships where utilization of floor space is an essential factor.

Components of the initial assembly were first mounted on one skid, structurally stressed for its static load as well as abusive loads in transit; however, the excessive weight involved and questionable loading facilities prompted an immediate change. Improved versions employ two mating sections which can be easily separated for shipment or flanged together on rig installations. One section consists of a standard skid mounted, power-driven, vertical cementing pumps, similar to that being used on the service boats. The mating skid consists of a horizontal duplex water pump arrangement, aso similar to the unit previously described, and a 20-barrel fluid measuring tank. Manifolding is restricted to the bare essentials, but is arranged for convenient valve manipulation. Elevated walkways, centrally located controls and compactness are a few of the finer points employed in this unit.

Total weight is 23,000 pounds with overall dimensions reading 14 feet 7½ inches x 10 feet 9½ inches. This unit is the equivalent of a standard land-based truck unit. Such units are operated and maintained by the cementing company's land-based crews who are transported to the drilling operation by speed boat when they are needed.

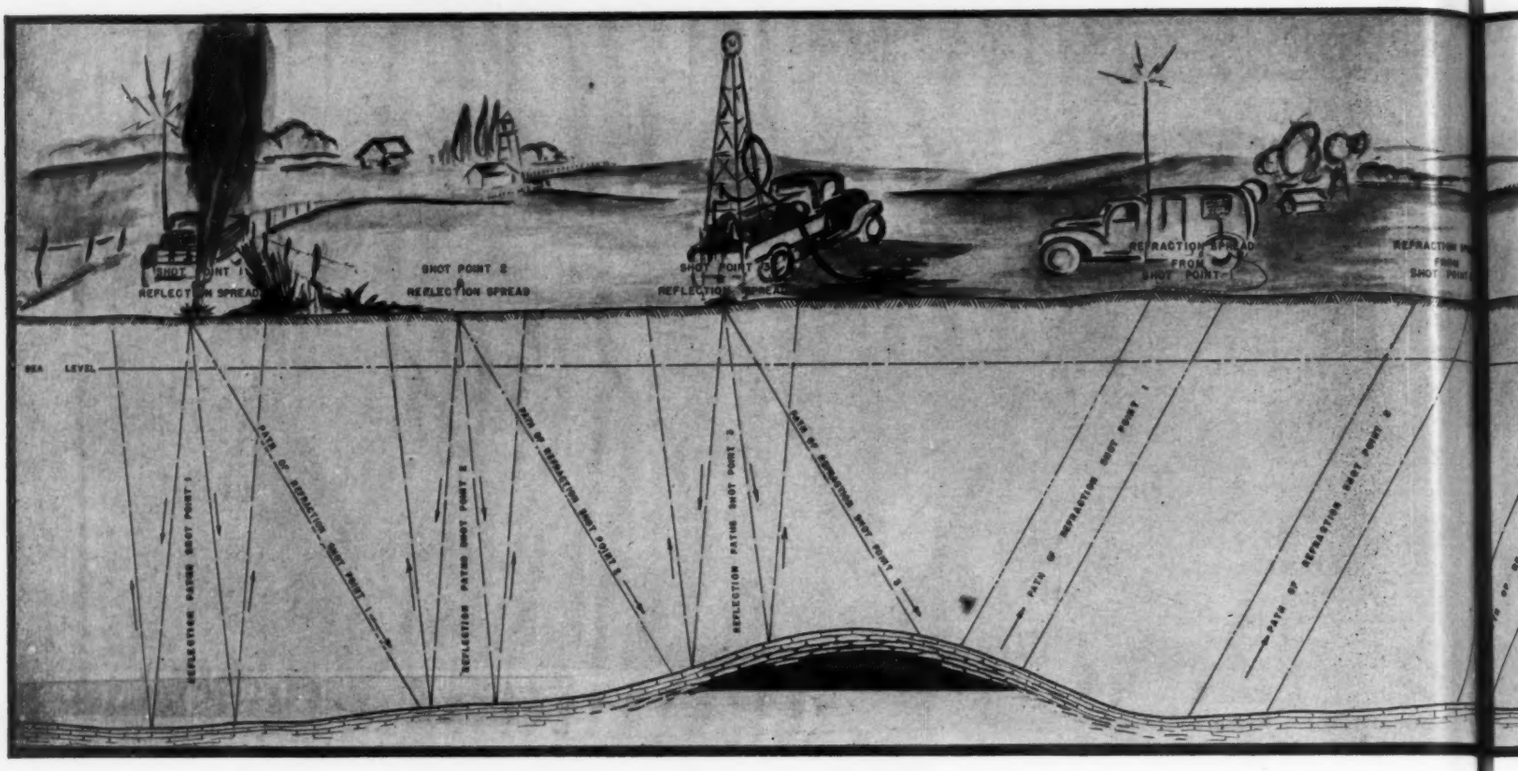


Figure 1: Schematic sketch showing paths of reflected and refracted energy from the postulated subsurface structure. Reading from left to right, Shot Point 1 illustrates detonation of charge with paths of reflected energy from the ends of a split reflection spread, also path of refraction wave from Shot Point 1 to high speed refracting layer and back to receiving seismometers shown opposite recording truck; Shot Point 2 shows similar paths as discussed for Shot Point 1; Shot Point 3 shows paths of reflected and refracted energy as discussed for Shot Points 1 and 2.

MODERN SEISMIC REFRACTION TECHNIQUES

By DR. SIDON HARRIS

MODERN seismic techniques applied to the exploration of the sub-surface for new petroleum reserves can be generally divided into two classes: namely, reflection techniques, and refraction techniques. Figure I is a schematic diagram illustrating the paths of the "shock waves" generated by the detonation of explosives in relatively shallow shot holes, for both reflection and refraction spreads. In reflection shooting the seismometer spread is laid out adjacent to the shot hole, normally being equally divided on each side of the hole, constituting what is generally referred to as a "split spread." The path of the shock wave from the shot point to the end seismometers of such a split spread is shown below Shot Point 1 in the left hand corner of Figure I; a similar set of reflection paths is shown under Shot Points 2 and 3. The path of a refraction is also illustrated in Figure I, emanating from Shot Point 1 and emerging at the spread of seismometers shown adjacent to the recording truck illustrated in the figure. Similar refraction paths are noted for spreads shot out of Points 2 and 3.

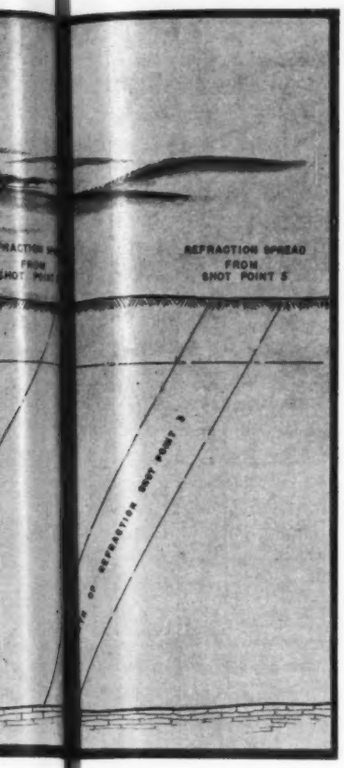
From the diagram, it can readily be seen that the essential difference between reflection and refraction techniques is in the distance between the shot point and the receiving seismometer spread. In the case of reflection techniques, the seismometers are set up very close to the hole; whereas, in refraction shooting seismometers are frequently set up four or five miles away from the shot point. In both reflection and refraction shooting, it is customary to detonate the explosives in shot holes usually drilled by portable rotary machines, as illustrated in Figure I and Figure XI.

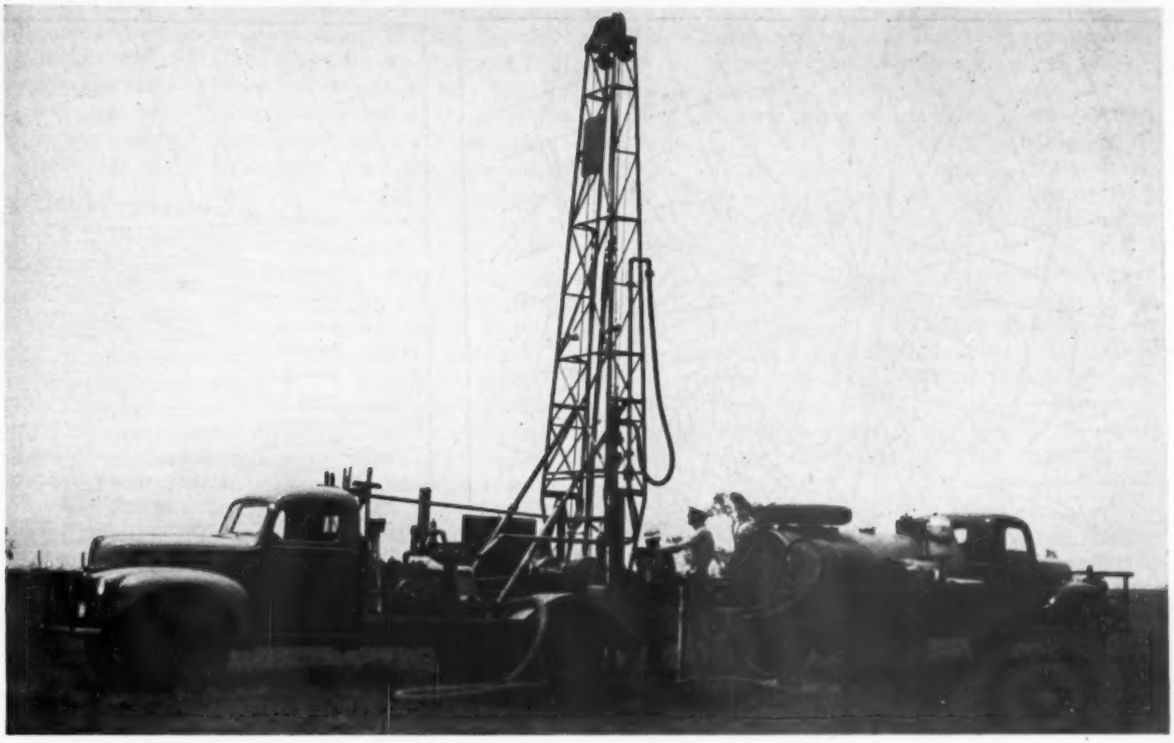
In the middle '20s the refraction technique was first applied to the exploration for new petroleum reserves in the Gulf Coast region of the United States and in certain portions of Mexico. The early technique relied principally on the "first break" method. In other words, it was necessary to actually observe on the seismogram the arrival of the true first impulse. The essential difference in the modern day technique lies in the fact that now it is not necessary to rely exclusively on "first breaks" but that second, third and later order "arrivals" are recorded on the seismogram, as illustrated in Figure II. As a matter of fact, the "true first break" is not even shown on this seismogram, being so weak in intensity that it does not record. The first visible refraction shown on the seismogram in Figure II, reading from left to right, is a relatively slow speed refraction coming from a rather shallow Permian horizon. The second visible refraction shown in Figure II, of a higher amplitude than the first visible refraction, is a higher speed refraction coming from the deeper Ellenburger formation. The seismogram illustrated in Figure II is typical of refraction records obtained in the Edwards Plateau Region of West Texas.

Field Operations

Modern day refraction techniques are employed rather extensively in this region. The rather large area, encompassing several counties and including several thousand square miles, is covered by a thicket deposit of "Edwards lime," varying in thickness from a few feet to 500 feet. In general, there is little if any surface soil on top of this heavy deposit of limestone. When the explosives are detonated in shot holes bottomed in this hard limestone, considerable unfavorable energy, normally referred to as "disturbance," is carried by the shallow limestone in a horizontal direction for a considerable distance. This "disturbance" interferes with, and practically eliminates, the reception of clear seismic reflections. However, in refraction shooting, the receiving seismometers are at such a great distance from the shot point that this horizontal disturbance either is completely attenuated or arrives so late that it does not interfere with the reception of of the desired refractions.

Other portions of West Texas, in addition to the Edwards Plateau, are covered by more or less





Seismograph portable shot hole drill and water truck in operation near Big Spring, Texas.

sporadic deposits of caliche of local significance. Again refraction methods are currently being used to explore these areas, as normal reflection techniques do not give satisfactory results. There are other provinces in the continental United States, such as a large section of Florida, where usual reflection methods also fail and where operators are currently using the refraction techniques. It is believed that modern refraction techniques can be applied successfully to a number of areas in foreign oil provinces where unfavorable surface conditions exist, and where reflection techniques do not give results. These refraction techniques have proved successful in detecting large sub-surface anomalies in West Texas and, therefore, should be worthy of consideration for exploring other provinces on a world-wide basis where similar surface conditions exist which are detrimental to the reception of usable reflection data.

A normal refraction seismograph crew operating in West Texas usually includes the following personnel and equipment:

Personnel

Seismologist
Party Manager
Permit Man
3 Computers
2 Observers
2 Assistant Observers
2 Recording Truck Helpers
Shooter
Shooter's Helper
5 Surveyors
5 Instrument Men
15 Chainmen and Brush Cutters
6 Drillers
6 Assistant Drillers
6 Drillers Helpers
Total 57 Employees

Equipment

2 Complete Recording Trucks
1 Shooting Truck
Complete two way radio communication between recording truck and shooting truck.
5 Surveying or engineer units
3 Portable drilling machines (Spudder type for the the Edwards Plateau)
3 Drill water trucks
Party Manager's Car
Permit Man's Car

In West Texas, the cost to the operator or oil company of such a crew as described above, will be approximately $40,000 per month. This figure covers the expense of permit fees, which average about $4,000 a month, and all supplies such as rock bits, drilling mud and explosives. Dynamite charges in this province vary from five pounds to as high as a thousand pounds per shot, depending on the sensitivity of the area. The explosive bill alone runs from four thousand to six thousand dollars a month. Additional surveying or engineering effort is usually required in refraction work, due to the fact that distances have to be accurately computed from shot points to receiving spreads, to an accuracy of at least twenty-five feet in twenty-five thousand. Some operators are now experimenting with refinements in surveying techniques, such as the use of Shoran. The estimated cost of refraction work in provinces outside the United States will vary proportionately from the base cost, depending upon general economic conditions of the respective provinces and transportation cost.

Figure 2: Typical refraction seismogram obtained on Edwards Plateau of West Texas. First visible arrival of refracted energy coming from relatively slow speed Permian horizon. Second high energy arrival being refracted from the Ellenburger. Bottom trace on seismogram is a special trace tapped from center spread, bypassing the automatic volume control.

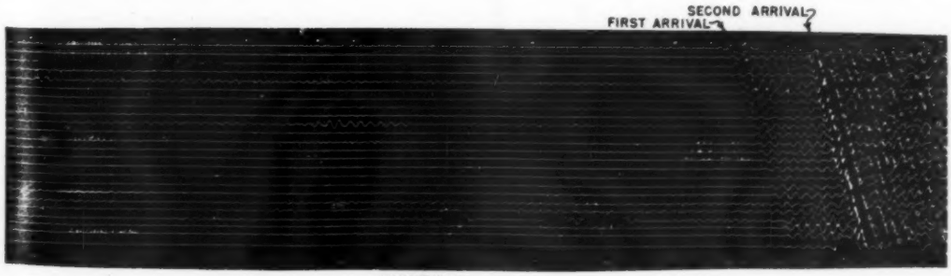


FIGURE II

Computational Techniques

Figure IV illustrates the path of a refraction from the shot hole shown on the left to the receiving station shown on the right. The approximate refraction paths are indicated for two positions of the high speed refracting horizon. Position A is for a horizontal flat bed, while Position B is for a tilted bed, dipping at an angle ϕ with the horizontal. In Figure IV it is assumed that we have a thin layer of weathering material with a velocity of V_o, followed by a few hundred feet of material with a velocity V_o, then a rather thick section with an average velocity of V_1 overlying the high speed refracting layer shown in the two Positions A and B referred to above. A simple form of first order computations is usually performed in the following manner. The time of arrival for the particular refraction under consideration, as shown in Figure II, is read directly from the seismogram

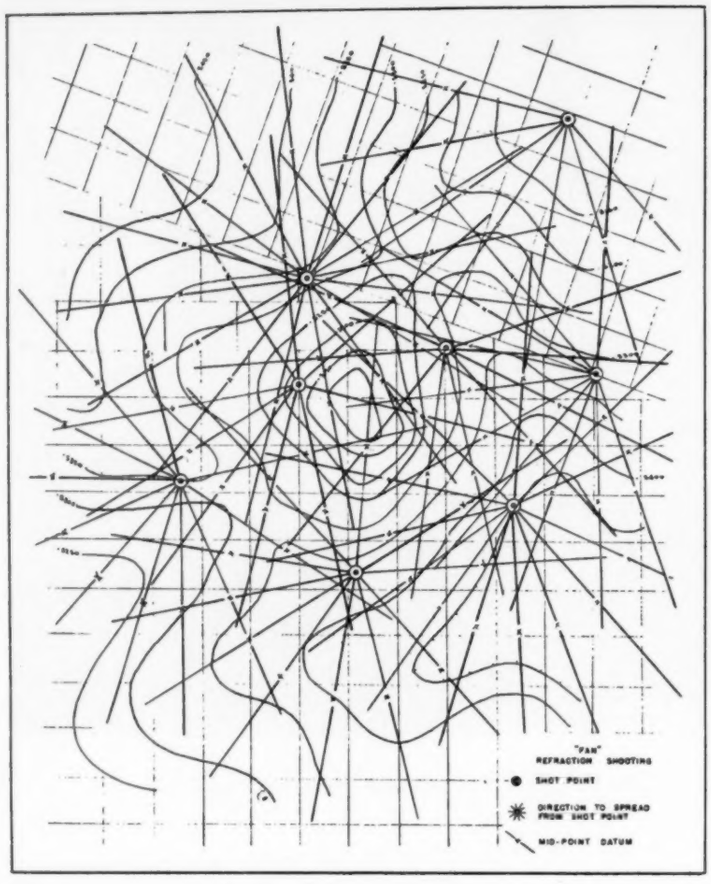


Figure 3: Diagram of reconnaissance fan shooting program, illustrating shot point distances, directions of corresponding spreads surrounding the respective shot points, mid-points and resulting postulated contoured subsurface map.

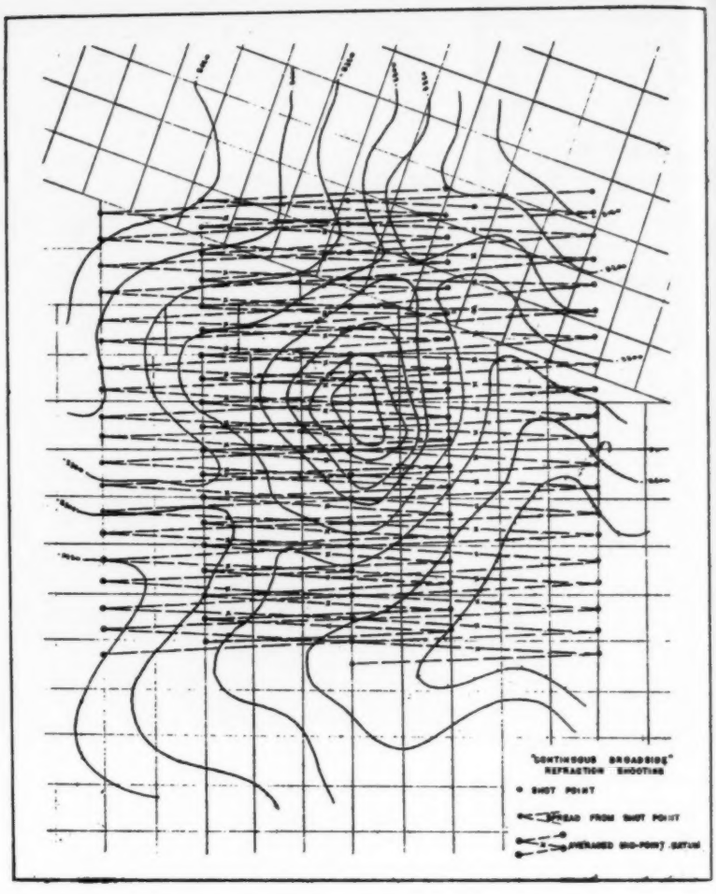
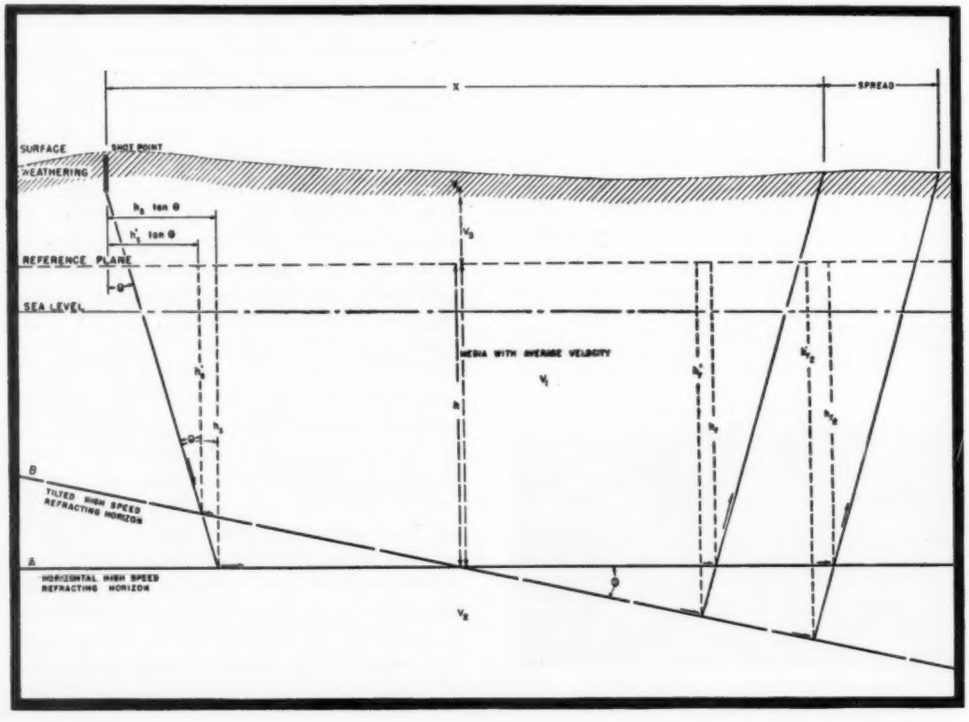


Figure 5: Layout of "broad side" continuous line refraction shooting, showing spreads, shot points, midpoints, paths between shot points and spreads and resulting postulated contoured map.

Figure 4: Schematic diagram of approximate refraction path from shot point to high speed refracting layer in Positions A and B, back to receiving stations at distance "X" from shot point.



to an accuracy of one thousandth of a second. This arrival time is then adjusted to refer the corrected total time to the reference plane shown in Figure IV. This correction is usually rather simply performed by adding the computed time it takes the wave to go from the bottom of the shot hole to the reference plane; and in emerging, to travel from the reference plane to the receiving seismometer. This correction is then subtracted from the observed arrival time read from the seismogram. Usually, an "uphole" shot is taken in the vicinity of each receiving station so that a proper correction can be made for the slow velocity weathered material lying close to the surface. It is usually safe to assume a more or less uniform velocity over a prospect from the base of the weathered zone to the reference plane, which is placed a few hundred feet below the surface. The depth of the refracting horizon, assuming a flat horizontal bed, can be approximately determined by the following relation:

$$1.\quad h = \tfrac{1}{2} \tan \theta \ (V_2 T_c - X)$$

Where:

h = depth of high speed horizontal refracting layer below reference plane.

$$\sin \theta = \frac{V_1}{V_2}$$

V_1 = average vertical velocity of overlying section between high speed refracting bed and reference plane (usually determined from adjacent velocity surveys made in deep tests).

V_2 = horizontal velocity of high speed refracting bed

T_c = corrected arrival time of refraction referred to reference plane

X = distance between shot hole and receiving station.

The depth h given in Equation 1 is then resolved to a sub-sea value by subtracting the elevation of the reference plane from the computed value of h. The first order approximation is then obtained by placing the sub-sea data (so computed) of the refracting horizon halfway between shot point and receiving station, which is usually referred to as the "midpoint."

As can be seen from Figure IV, there can be considerable variation in the depth of the refracting bed between the shot point and receiving station, especially when the recording distance is four to six miles in length. After the preparation of the first order approximation "midpoint map," it is advisable to apply further corrections. The first step in this procedure is to draw the "Straws" on the map. The "Straw" is defined as the distance along the refracting bed that the wave actually travels; which will be $X - 2h(\tan\theta)$ for a horizontal refracting bed as shown in Figure IV. A rough approximation can be assumed that the depth $h_s' + h_r' = 2h$; where h is the same as defined in Equation 1 and as shown in Figure IV. Therefore, if an initial depth h_s' is assumed at one end of the "Straw," it automatically determines the depth at the other end; and if enough of the "Straws" intersect in the approximate vicinity of the respective ends, it is possible to run traverse completely around the prospect. If a misclosure occurs, it can then be adjusted out in a reasonable fashion and a second order approximation contour map prepared, which is usually referred to as a "Jack Straw" map. By a quick glance at Figure III, it is easy to see how the name "Jack Straw" was applied to this type of interpretation.

Still another refinement in the computation of seismic data can be obtained by the computation of "dip" from a single spread or profile. Referring to Figure IV, it can readily be seen that the arrival time of the last seismometer will be greater than the arrival time of the first seismometer even when the refracting bed is horizontal. This increment in time is referred to as the "normal moveout." This difference in arrival time of the first and last trace can be observed at a glance by inspection of the seismogram illustrated in Figure II. After proper corrections have been made to allow for differences in elevation of the first and last seismometers, and for variations in the weathering, the observed moveout across the record can be accurately computed. If the true velocity of the refracting surface is known, the "normal moveout" can also be accurately determined. If the corrected observed moveout is less than the normal moveout, the spread is laid out "up dip"; in other words the last seismometer is up dip in direction from the first seismometer. If the spread is laid out "down dip," as illustrated by Position B of the tilted high speed horizon in Figure IV, the corrected observed moveout will be greater than the normal moveout. Thus, if the true velocity of the horizontal bed can be determined, dips can be computed under every spread, from which a "dip map" can be prepared.

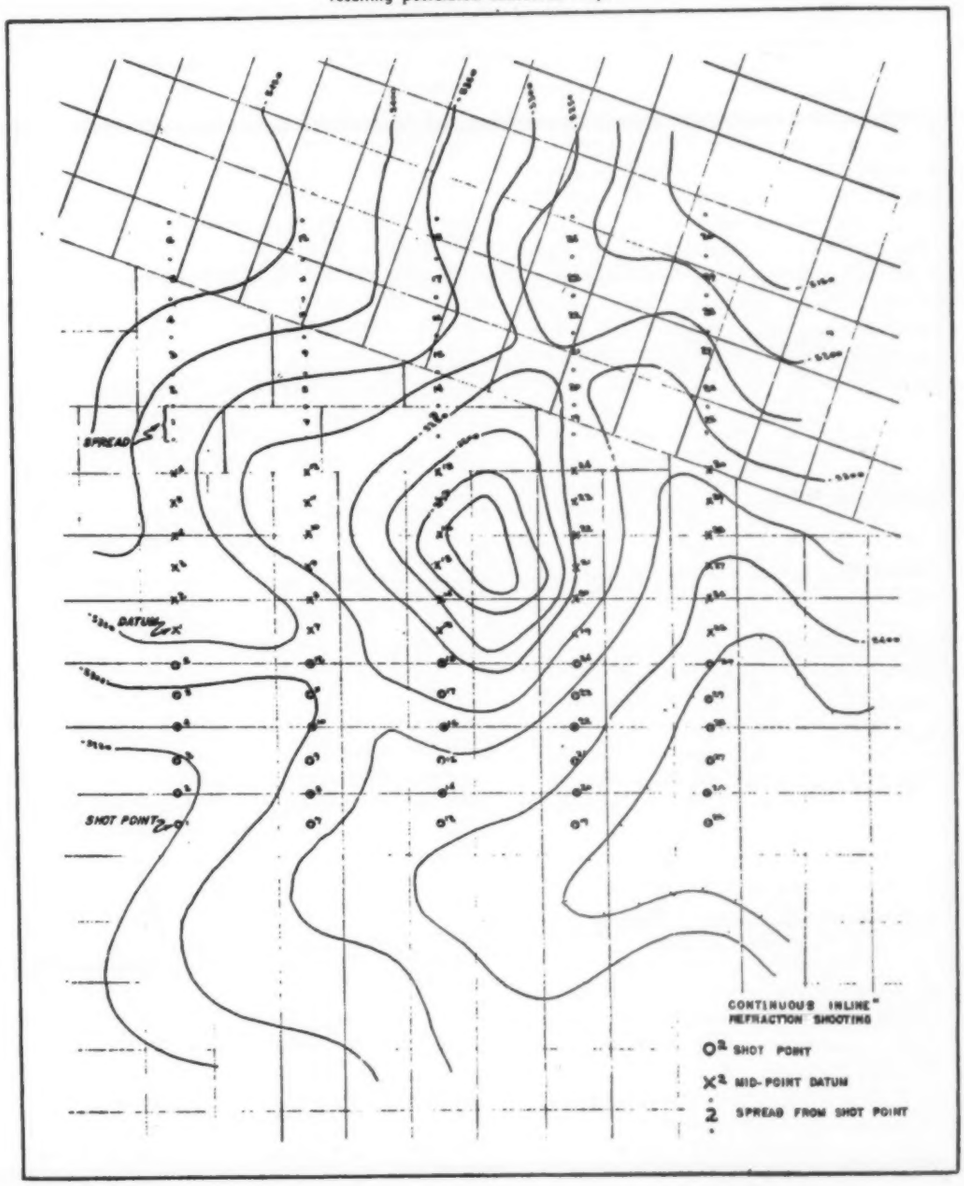
Other Applications of Refraction Techniques

Where satisfactory correlations can be obtained at a desired depth, it is customary to run a reconnaissance pattern of "fan shooting" over the area. This method is illustrated in Figure III, where the shot points have been indicated as shown and "spokes" of the wheel illustrate the direction and distances of the various spreads of seismometers from the respective shot holes. Small x's along these spokes indicate the midpoint between the shot hole and the spread, where the computed sub-sea values are placed in preparing the contoured map as postulated in this figure. Figure III further illustrates a possible reconnaissance density of fan shooting to detect a reasonable size postulated structure as shown by the contours. It is often possible to correlate the various refraction arrivals shown on the seismograms, as illustrated on Figure II. The depths of the refraction horizons at the various positions are then computed, placed on the map and contoured.

After the first general reconnaissance work, it is frequently necessary to do greater detail even with refraction shooting. Several forms of continuous refraction techniques have been developed. Figure V illustrates one method commonly referred to as the "broad side method," where the seismometer spreads are set up on a line parallel to the line of shot points; the seismometer spread being laid out in an adaptation of the off-set split spread. Thus by shooting all the spreads on one line from the shot points on the corresponding off-set line, and then reversing the procedure, a continuous correlation can be obtained from one record to the other with a 100% sub-surface interlock; thus preventing any possible miscorrelations, and of course giving fairly close control. The first computations can be placed at the midpoints shown by small x's in Figure V and the corresponding postulated contour map prepared. Other second order approximations described above, such as the "Jack Straw" interpretation, can be applied to this method.

Another form of continuous refraction shooting is illustrated in Figure VI. This method is called the "in line" method of continuous shooting where the shot point is moved each time along the line of shooting a distance equal to the

Figure 6: Plan showing layout of "in line" continuous refraction shooting, showing shot points, midpoints, spreads and resulting postulated contoured map.



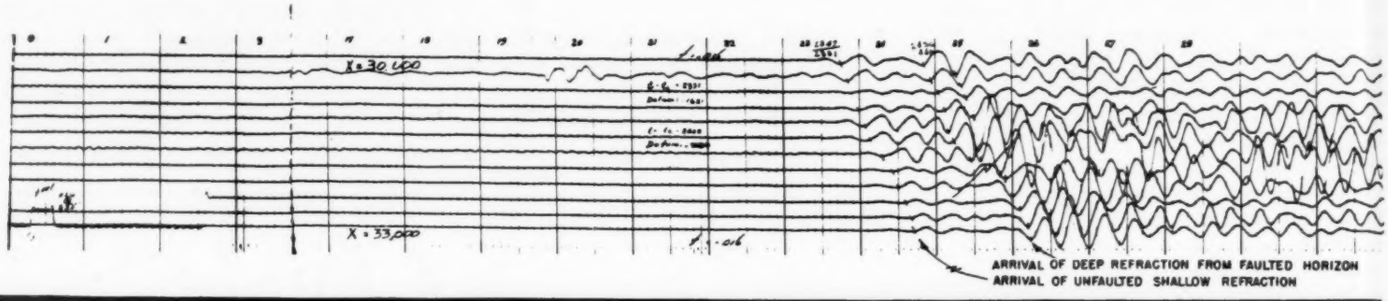
spread of seismometers, and at the same time the seismometer spread is also moved; thus keeping a fixed distance between shot points and seismometers. This process is continued until reaching one end of the line; it is then turned around and the procedure reversed until reaching the other end of the line. Thus, except for the ends of the line where no overlap is obtained, a continuous 100% time tie or interlock is obtained by this technique, so that here again there is very little, if any, chance of a miscorrelation if the records are of sufficient quality and clearness. Figure VI shows several of these "in line" continuous layouts. It will be necessary, in working out a detailed program such as illustrated in Figure VI, to eventually lay out intersecting horizontal lines. However, for clarity sake, these lines were not included. The first order approximation for this technique again is the use of the midpoint as previously described. After the first approximation has been worked up, other refinements, such as the Jack Straw adaptation, can be applied.

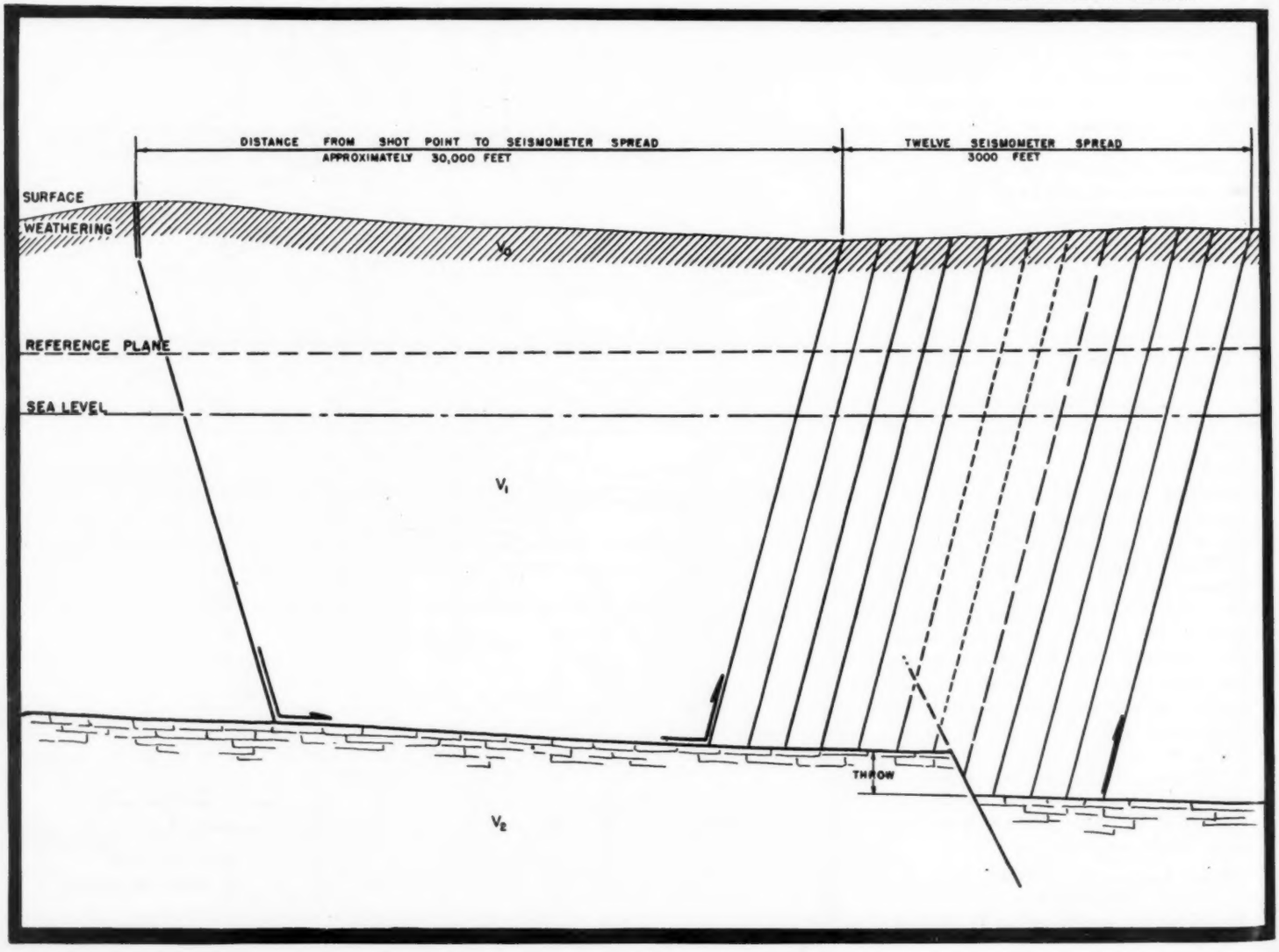
Figure VII includes a refraction seismogram showing a faulted condition in a high speed refracting layer, illustrated in the schematic diagram shown immediately below. The first arrival, reading from left to right, which is marked on the seismogram, is a shallow slower speed bed which does not show faulting; the second arrival, of higher amplitude, does indicate quite clearly a faulted condition.

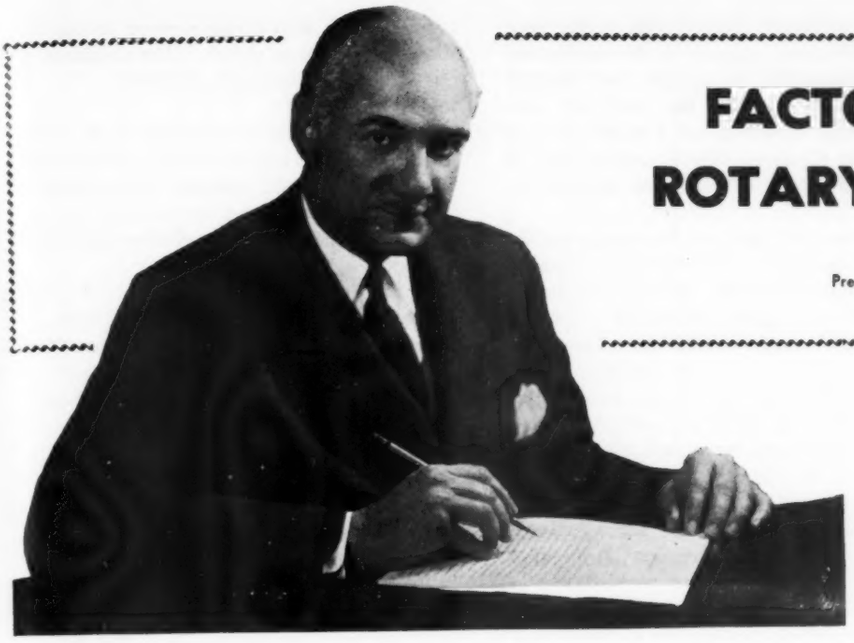
To confirm a possible fault, it is wise to shoot a reverse spread in the opposite direction. In a number of cases, faulted zones do not give very clear reflections, and at times when it is impossible to accurately delineate the faulted condition by use of reflection methods, it is occationally possible to obtain more accurate data by use of the refraction technique, as illustrated in Figure VII.

As can be readily deduced from the preceding discussion, the refraction method does not have as great a delineating power as the usual reflection techniques. Therefore, the majority of present day refraction work is principally confined to areas which are unfavorable to reflection methods. However, in certain virgin provinces it may be economically sound to survey for large anomalies by use of the refraction "fan shooting" technique as illustrated in Figure III, even where satisfactory reflection data is obtainable.

Figure 7. Seismogram showing refraction from deep faulted horizon by attached schematic diagram.







FACTORS GOVERNING ROTARY DRILLING RATES

By J. E. BRANTLY
President, Drilling and Exploration Company

BEGINNING in 1938, almost ten years ago, and extending into early 1939 the writer, together with Edgar H. Clayton, undertook to determine the reasons for the very considerable increase in rate of penetration that had taken place within a few years in wells drilled by the rotary method. The object, of course, was to determine the most important factors concerned in the increase, analyze them in fundamentals and detail and endeavor to improve further the rate of penetration and, in consequence, to reduce the cost of drilling wells.

The year 1932 was selected as the beginning of the study because it happened to be the earliest for which satisfactory and usable records of well drilling operations could be found. The records of wells completed up to February 1939, when the study was concluded, were used; thus the period extended over six or seven years. The results were presented in a paper read at American Petroleum Institute meetings in 1939.*

During the period covered by the study it is probable that there were more radical changes and improvements in rotary drilling machinery and practices than during any like period before or since. During this time large fluid volumes came into general use with the advent of 20-inch pumps and 350-pound steam pressure. These units had been developed somewhat earlier during the commencement of drilling in the Oklahoma City field but did not come into wide service until some years later. The actual cutting tools or bits were improved enormously. Drag bits were faced with hard alloys such as stellite and tungsten carbide, and rock bits were improved in material and design and their teeth were likewise faced with these hard metal alloys. High speed bit rotation became feasible through the development of the directly-driven rotary table units. The use of long drill collars permitted more weight to be carried on the bit and protected the drill pipe against various types of fatigue caused primarily by running the tubular shaft in compression and "stall shocks." New methods of attaching tool joints to the drill pipe were developed, thus eliminating many fishing jobs and enabling the operator to submit the pipe to somewhat more rugged use.

Vast improvements were made in machinery enabling faster round trips and eliminating much shut-down time. The height of derricks was increased and more floor space was added. Pump liners were greatly increased in hardness on the working inner surface, thus extending their useful life as well as the useful life of the rubber pistons which had also been improved. The chemistry of rotary drilling fluid or, as it is more frequently called, "mud chemistry" was developed. The importance of a mud-laden fluid of proper characteristics was just beginning to be recognized in 1932.

Improved steels were employed in all machinery and equipment from pipe wrenches to drawworks. Methods for uniform rate of feed were developed.

In addition to these many improvements in mechanical equipment and the manner of their use, there was the vastly important improvement in personnel and no small part of this improvement was the reduction of work hours or tours from twelve hours each day to eight hours each day. Drilling engineers received recognition. Drilling practice statistics were studied. Basic principles of correct practices were established. Rule of thumb methods were discarded and uniformity in the use of the best practices came into vogue. The drilling of wells became or was made, a highly technical operation.

These studies, concluded in early 1939, indicated an average increase on well conducted operations of 123.7 percent over corresponding operations only six years previously. Drilling data on more than 500 wells were used. The wells studied were drilled in typical oil fields by representative operators in Texas, Oklahoma, Louisiana, New Mexico, Wyoming, Kansas, and particularly in California. It was the last-named state where the greatest number of improvements in drilling practices and drilling machinery originated after 1933, though the Gulf Coast certainly was equally if not further advanced in mud control.

In formalizing the studies undertaken, five factors were used, namely, personnel, equipment, rotating speed, volume of drilling fluid and weight on the bit. Hole sizes, character of drilling fluid and other factors were likewise important but could not be readily isolated for study and were, therefore, included with the other five factors. Actually when the studies were completed, we found that personnel and equipment had to be combined into one factor. The relation of rate of penetration to rotating speed and to mud volume were both easily isolated and, therefore, could be studied quite independently. It was found that the factor of weight on the bit could not be isolated with any degree of certainty. The studies resulted in the following tabulation:

Personnel and equipment	55.5 percent
Rotating speed	39.6 "
Drilling fluid, volume	28.6 "
Weight on bit	Included in above figures
Total increase	123.7 percent

It was, of course, not assumed that any such accuracy as the fractional percentages indicate was reached; the figures are approximate and indicative. The percentages were used as calculated. In discussing these several factors in this paper, the order of discussion will be reversed, beginning with weight on bit.

It was found in the earlier studies that the weight carried on the bit was the most difficult to evaluate for the reason that during the period covered by the study drilling weights generally changed very little and when they did, at least in the direction of more weight, it was usually necessary to change some other factor such as fluid volume in order to render the increased weight effective. For example, in areas like Kettleman Hills, West Texas and the Gulf Coast there was little variation over the six years in drilling weights employed. In the Brown Shale of Kettleman Hills about one point of

* "A Preliminary Evaluation of Factors Controlling Rate of Penetration in Rotary Drilling" by J. E. Brantly and Edgar H. Clayton. Presented at Spring Meeting API, 1939. May be found in API "Drilling and Production Practice," 1939.

weight was used in 1937, yet the rate of penetration increased from one foot per hour to as much as four or five feet per hour. In West Texas it was customary to carry six to ten points of weight (eight to twelve tons) in the earlier part of the period studied, and there had been little change in this practice at the end of the study, yet rates of penetration increased materially and, therefore, must have been accounted for by other factors. In the Gulf Coast country where formations are soft, very little weight was carried on the bits in the earliest wells of which we have record, and still very little weight was carried on the bits in the later wells, and yet there was a very substantial increase in rate of penetration. In some fields there was considerable increase in weight accompanied by increase in rate of penetration; however, at the same time this increase was equally if not more importantly accounted for by increase in fluid volume and increase in rotating speeds.

In some fields there have been no considerable changes in weight carried on the bit in usual practices, though in others there have been substantial increases. In such fields as Paloma in the San Joaquin Valley of California and some of the areas in the Los Angeles Basin, weights increased from one or two points ten years ago to three or four points or even more in some cases at the present time. While the weight carried is still comparatively low, yet in percentage it has doubled. Rate of penetration has likewise doubled, as have fluid volume and rotating speed.

Interesting experiments have been carried on in the limestone and dolomite drilling of West Texas by the use of very long drill collars and twenty or more tons of weight on the bit. This has required a specially built up drilling shaft to permit the excessive weights. It is understood that one operator has drilled a number of wells in this manner and that, while the results are not entirely conclusive, some increase in rate of penetration was obtained. It is not known that any other operators have gone to this practice.

In addition to the actual drillability of the formations, there are other factors to be taken into consideration. We may assume that the correct drilling speed, the maximum fluid volume and the proper bits are used in a well drilling in relatively steep beds of changing hardness. If the hole is to be drilled straight, there is a maximum weight that may be carried, and this weight may be as little at 25 percent of the amount of weight concentration in the drill collars above the bit. Also there is a limit to the amount of drill collar that can be so used, in view of the fact that beyond some certain length of this heavy part of the shaft, it then becomes for all practical purposes a shaft in the same category as the drill pipe, and the point of equilibrium between the suspended weight and supported weight, or the center of gravity of the former, will be sufficiently far above the bit that the drill collar no longer acts as a pendulum hanging straight in the hole and leaning against the up-dip side of the bore.

In hard formations the weight that may be effectively carried on the bit is limited by this same factor. The load capacity of the cutting tool itself is limited by its strength and bearings. At the other extreme in the usual soft Gulf Coast drilling, weight is not a factor since, as it is usually expressed. "the bit cannot keep up with the hole," if there is sufficient fluid volume.

An important sub-factor of this weight on the bit is the uniformity with which it is applied to the bottom of the hole. If the proper weight to be carried on a given cutting tool is six tons and the actual weight carried varies from three to nine tons, as is usually the case in the ordinary handbrake feed, then the bit is cutting at maximum efficiency only at one point throughout its weight stroke, and the overall efficiency will be less than the normal. Even at this time, nine years after the conclusion of the original studies, weight carried on the bit has shown little change from those practices during that period, and it is doubtful that any increases in rate of penetration from 1939 until the present time are due to a considerable extent to this factor.

Though we have not had the benefit of a detailed study during the past few years and in consequence must speak in generalities only, the statement may be made again that in general practice (not experimental drilling) the most difficult mechanical factor to evaluate separately is that of weight on the bit and that as weight is increased fluid volume must also be increased. The reverse is not true.

The percentage of increase in rate of penetration due to increased volume of drilling fluid between 1932 and 1939 was calculated to be 28.6 percent.

The following five numbered paragraphs are quoted from the paper written on the above referred to studies:

(1) That, in hard-rock fields, increased rates of penetration depend upon the personnel and improvements in bits and drill pipe. Rotating speeds and fluid volumes apparently have reached their upper limits, as has weight on the bit in many cases.

(2) That, in rock-bit drilling in relatively soft material, increase in values of the four factors will result in an increased rate of penetration, although there undoubtedly will be maximum limits for all of these with the exception of personnel.

(3) In drilling formations of the above types or softer, with drag bits, the same conditions apparently will obtain; i.e., by increasing the values of the several factors, an increased rate of penetration will result.

(4) In plastic formations, brittle shales, limestones having conchoidal fracture, and some other somewhat similar formations, rate of penetration may be increased by improvement in the personnel and bits, by increased rotating speeds to the practical maximum, and larger fluid volume, together with higher pressure jetting from the fluid nozzles of the bit. The weight on the bit may not be increased profitably.

(5) In plastic, clayey, silty and shaley formations, rate of penetration increases depend largely upon increased fluid volumes, jetting action of the fluid on bottom and character of the fluid. The use of the proper type of short drag bits is assumed.

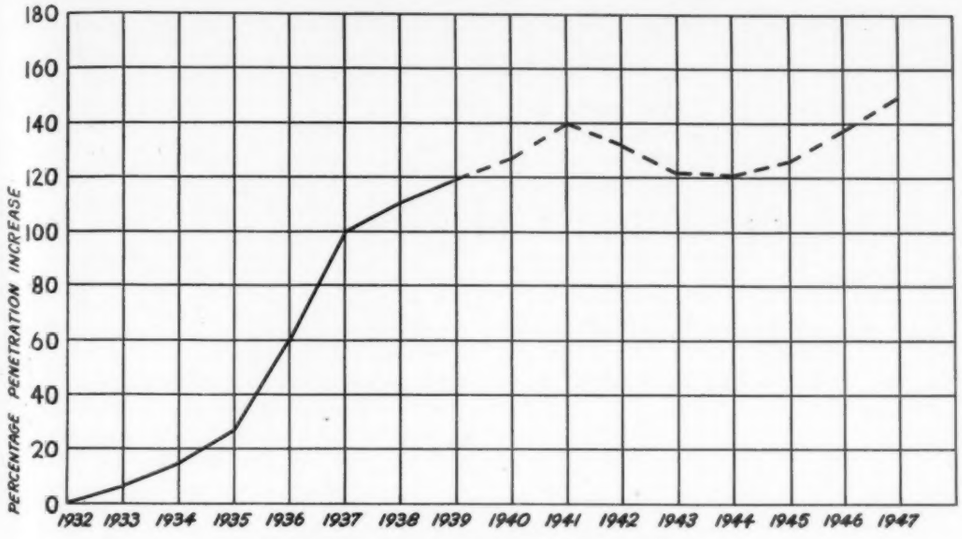
In the above five paragraphs which cover five different types of drilling, the opinion is expressed that in all classes of drilling with the exception of hard rock, increases in fluid volumes above the then normal maxima would increase the rate of penetration. It has been learned since that even in hard rock drilling, increase in fluid volume (and decrease in viscosity) has helped rate of penetration considerably. For example, in the hard rock fields of West Texas 400 gallons per minute in a 7⅝-inch to 8⅝-inch hole was formerly customary. This volume has been increased to 600 gallons per minute or more, and the rate of penetration has increased as much as 20 to 30 percent apparently due to this one factor.

In other types of drilling it has been found that rate of penetration increases almost directly with increases in the circulating fluid volume, assuming use of a proper fluid. In some fields in the softer formations it was formerly customary to run one 800 gpm pump. It is now common practice to run two 800 gallon pumps in parallel resulting in probably 1200 to 1400 gallons per minute, allowing for a decrease in efficiency for pumps in parallel. Rate of penetration has thereby been increased very considerably, though probably not in direct ratio.

Since 1939 drilling fluid volumes delivered into the drill pipe have increased materially, particularly on power rigs. The rate of penetration has likewise increased materially. Approximate percentages cannot be given, for they have not been studied in sufficient detail; however, it seems that the statement is still true that in general practice the maximum efficient volume of rotary drilling fluid is not yet in use. Fluid of proper characteristics must be employed. Of course, in many areas, many fields and with many tools there are factors other than the formation itself which limit the volumes that may be satisfactorily circulated.

At the present time power pump capacities are being increased by strengthening the power-end of the pump as well as by increasing the volumetric displacement. In order that the power rig may drill with the efficiency of the steam rig under large and deep hole conditions, still further increases in capacities are necessary.

Probably the most controversial of the various mechanical factors affecting rate of penetration is rotating speed. In the early days of drilling by the rotary method there were two distinct types of drilling equipment, each of which employed certain practices quite different from those of the other. The first to be de-



Rate of Penetration — Increase Trend — Rotary Drilling
Note similarity of angle of graph for periods 1932-1935, 1937-1941 and 1944-1947. Period 1934-1937 saw greatest improvement in equipment and drilling practices in history of industry. Period 1941-1944 saw decline in personnel value owing to the loss of many men to armed services and their replacement with inexperienced men. In 1947 the industry has recovered and gone somewhat beyond the drilling efficiency of 1941. Graph 1932-1939 taken from API paper referred to on page 79. Remainder of graph developed from fewer wells and is less definite.

veloped and perfected were coring machines having bits set with carbons or black diamonds. These machines used relatively small drill "rods" and small bits set with diamonds. They circulated clear water and rotated at speeds varying from 200 to 400 rpm. Little weight was carried on the cutting tools.

The other rotary drilling equipment was the type developed for the drilling of oil wells, and in the beginning employed very crude machinery and used drilling practices that were set largely by the limitations of the equipment. Rotating speeds were as fast as the "single barrel" engines could turn the pipe, usually considerably less than 100 rpm. Pumps were able to circulate not more than 200 to 300 gpm of whatever drilling fluid the hole would make. Bits were tempered steel fishtails of poor reliability. The edge of one would break off; of another it would turn over, and maybe two bits would "make a little hole."

This was standard equipment used until the late 1920's, at which time twin engines were developed and other equipment and machines were perfected to the point that greater flexibility in drilling practices, particularly in fluid volumes and rotating speeds, might be used.

At about the same time diamond drilling equipment was tried out, particularly in Mexico and Venezuela. The advantages of high-speed rotation were learned, and in consequence in the early thirties these high speeds were introduced into the drilling of oil wells with the usual drilling equipment. The range of speeds desired was not possible with the conventional rotary table drive through the hoist and from the hoisting engine, and so the independently-driven table was developed, first in 1931 in Venezuela. A more highly perfected machine was placed in service in Kettleman Hills, California, in 1934. Since that time this equipment has come into general use on the more difficult operations and now permits rotating speeds as high as 500 rpm or even more. It seems doubtful, however, that speeds in excess of 400 rpm are practical.

There is no correct rotating speed that is suitable for all types of formations lying in their various attitudes. For this reason the old type conventional equipment cannot have the same efficiency in rate of penetration when rotating speeds above 150 rpm are required. It may be stated broadly that the hard formations such as limestones, dolomites, anhydrite and sandstones are best penetrated with rotating speeds that vary from 40 to 100 rpm. At the other extreme hard brittle shales, particularly those with conchoidal fracture, may be most rapidly penetrated at the other extreme of 300 to 400 rpm. The slow speeds in hard formations require heavy weight. The high speeds in the less resistant, more brittle formations require light weight. Between these two extremes there are many variations.

Over the same period covered in the well records studied in 1939, machinery permitting the flexibility of rotating speeds as developed in those areas that require high-speed rotation for maximum rate of penetration was put into service and drilling efficiency increased materially. For example, the rate of drilling in the Brown Shale of Kettleman Hills increased as much as 300 to 400 percent by increasing rotating speeds from about 125 to 300 rpm. Weight on the bit was not changed, though drilling fluid was increased probably 50 percent.

The principal increases in rate of penetration due to increasing rotating speeds began in the thirties. Since that period high-speed rotation, where advantageous, has become general practice.

It may be said then that in areas for formations where rotating speeds of less than 150 rpm are best suited for the conditions, there have been no increases in rate of penetration that may be credited to rotating speeds. On the other hand, in areas and formations where high rotating speeds are best, substantial increases are evident. High-speed rotation and light weight are especially useful in drilling steeply dipping beds and maintaining a straight hole.

In conclusion, on rotating speeds it may be stated that within the past ten years the importance of the rotating speed of the bit as a factor in rate of penetration has been more fully realized and that speed which is most suitable for the formations being drilled now is usually employed.

There appears to be little further opportunity for improvement in the matter of rotating speeds except in using those which are best suited to each particular problem. The machinery with which these required speeds can be accomplished is available.

The great improvements in steam-driven drilling equipment were effected between the years 1928 and 1940. Since that time there has been little improvement in above-ground equipment, and, therefore, there have been no increases in drilling efficiency since 1940 that can be attributed to the above-ground machinery alone.

On the other hand, power rigs have shown great improvement. This is true of the prime movers, pumps and hoists. This improvement has been so considerable that power rigs can now compete with steam even in relatively difficult deep holes, while in shallow operations they can be more economically operated. But the improvements in above-ground equipment on power rigs, with the sole exception of the pumps, has had to do primarily with overall time and has not affected actual rate of penetration.

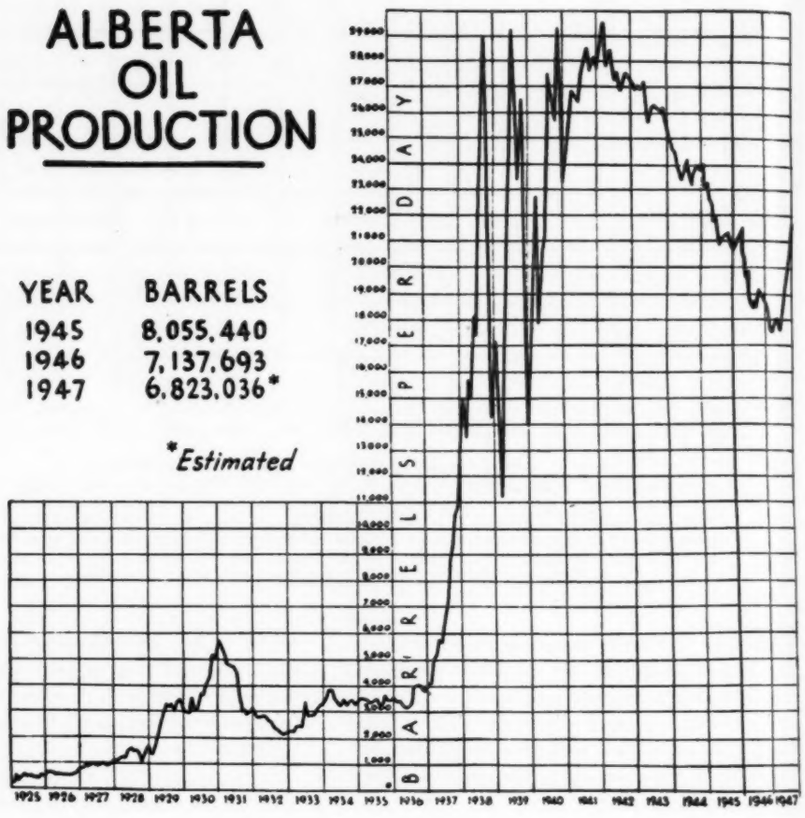
Power rigs until quite recently have used pumps that were inadequate in brake horsepower input and in consequence in hydraulic horsepower output. Even now pumps are inadequate for the deepest holes but are being rapidly increased in power-end capacity to the point that they may compete with the heaviest steam pumps. Manufacturers are now building power-ends that will easily accommodate the brake horsepower delivered by a 750-horsepower internal combustion engine. Large volume at high pressure is still unobtainable though the problems of compounding are being studied.

It may be said in general that for the account of above-ground machinery the improvements in rate of penetration within the past ten years are those which may be accredited to larger and better pumps on power rigs.

The story on below-surface equipment is somewhat different, though the great improvements, both in equipment and rate of penetration, were made prior to 1940. The practices and tools developed during that period have become more generally used since. For actual improvement in penetration rate since 1940, the greatest credit doubtless is due to bits themselves. The alloys

(Continued on page 102)

Woodbend well north of Leduc field coming into production.



Alberta production has been rising since midyear after a long period of decline.

NEW PETROLEUM ERA OPENS FOR CANADA

By J. L. IRWIN

ALBERTA has been producing oil for thirty-three years. Over this period of time there have been many encouraging milestones in the history of her oil development. Another one appeared in 1947 which may prove to be most important.

This was the discovery of Alberta's Leduc field, the first well coming into major production on February 13, 1947. The discovery was made by Imperial Oil Limited. Site of this first well was about eighteen miles to the south of Edmonton, capital city of Alberta. The oil was of high quality, around 40° in gravity, free of sulfur and with a definite lubricant content. Recoveries were made at depths around 5,050 and 5,350 feet in the Devonian limestone. It was a two-zone field. Drilling presented no serious problems, and wells were completed in six weeks to two months time. It was a most opportune arrival for before the year was out, it was made evident that this was Alberta's second major field, long sought to follow Turner Valley.

By November an eight-mile pipeline to railhead was completed and immediately production totals increased. Added to this the greatly extended Lloydminster oil area was increasing production on a major scale. The Princess field in the south displayed increasing promise, and in the prolific northern end of Turner Valley the Home Oil Company was expanding its production and thereby helping to mitigate the decline of that famous field. By the latter part of the year Imperial Oil had started work on the erection of a major refinery in Edmonton at a cost of several million dollars, so that increased production could be taken care of. The entire oil picture of Alberta was in process of transformation.

In the final quarter of the year production totals began to mount. In October, for the first time in years, an increase was shown over the corresponding month of the previous year. With Leduc's pipeline accelerating production and aided by increases from other areas, output is expected to continue its growth, and the future for the oil industry in Alberta looks more hopeful than it has for many a year.

Production figures for the past two years, with December, 1947, estimated, are given in the following table:

Alberta Oil Production

(Quantities in barrels of 35 imperial gallons)

Month	1946	1947	Changes
January	660,645	563,172	— 97,473
February	593,367	504,847	— 88,520
March	644,205	542,175	—102,030
April	601,955	523,960	— 77,995
May	598,018	560,579	— 37,439
June	582,149	540,720	— 41,429
July	591,772	545,039	— 46,733
August	575,489	554,650	— 20,839
September	565,854	557,357	— 8,497
October	583,328	618,777	+ 35,449
November	576,214	627,113	+ 50,899
December	564,697	684,647*	+119,950*
Totals	7,137,693	6,823,036*	—314,657*

Value of production for 1946 $14,348,069
Value of production for 1947 $14,600,000*
* Preliminary figures

Oil decline for Alberta at the close of 1946, in comparison with 1945, was nearly a million bar-

rels—917,747 to be exact. The decline at the end of 1947, on a similar basis of annual comparison is estimated above at 314,657 barrels.

The difference of 603,090 barrels is an outstanding figure in consideration of the fact that it was not until the beginning of November that Leduc's major production was really able to get into its stride when pipeline transportation from the field started to operate. The current year should reveal a large increase in annual comparison.

Alberta's daily average production opened in January, 1947, with 18,167 barrels, dropped in April to 17,466, but by December had risen to 22,085 barrels.

Alberta's Annual Oil Production Totals

(Quantities in barrels of 35 imperial gallons)
1914 to 1947, inclusive

1914-21	56,675	1934	1,266,049
1922	15,796	1935	1,263,968
1923	10,003	1936	1,320,428
1924	17,749	1937	2,796,874
1925	180,885	1938	6,743,101
1926	219,598	1939	7,593,492
1927	332,312	1940	8,495,207
1928	489,532	1941	9,908,643
1929	999,523	1942	10,136,296
1930	1,436,259	1943	9,674,548
1931	1,454,816	1944	8,788,726
1932	918,154	1945	8,055,440
1933	1,012,784	1946	7,137,693
		1947	6,823,036*
		Total	97,147,587*
Valuation of above grand total			$166,288,485*

* Preliminary figures

Until 1936 Turner Valley's production totals represented recoveries of naphtha from wet gas. On June 16, 1936, however, the Turner Valley Royalties well found crude oil in encouraging quantities on the western flank of the limestone structure.

From that date on totals mounted until the peak year 1942, when the annual total rose to 10,136,296 barrels, practically all of it Turner Valley and the bulk represented by Valley crude oil recoveries. After 1942 production started its decline.

Markers to determine the southern, eastern and western boundaries of Turner Valley are more or less established. This is not the case in the north where the Home Oil Company has been active. Six new producers have made their appearance in recent months as a result of Home's developments. During December, 1947, three wells were brought in by the company in the Valley together with its first major producer in the Leduc field. Three new Home wells are to be drilled now in the north end of Turner Valley, Nos. 31, 32 and 33, all about a quarter of a mile to the west of the producers recently completed. With rising prices for crude more drilling is looked for now in Turner Valley.

First well in the Leduc area, based on seismograph surveys, was started November 20, 1946, by Imperial Oil Limited. At 3,400 feet heavy gas pressure was encountered in the Viking sand of the Upper Cretaceous. Going slowly with continuous coring, the well was carefully tested. The top of the Devonian limestone was reached at 4,390 feet. The next few hundred feet gave showings of oil, gas and water. Next was an Anhydrite bed and about forty feet of red shale. The lime was reached again at 4,995 feet. Porosity developed, then increased and drilling stopped at 5,066 feet for a drillstem test.

The test was most encouraging. Gas rushed to the surface followed by a flow of greenish-brown oil. Casing was set at 5,029 feet, the plug drilled and on February 13, 1947, the discovery well was brought in. Flush production was at the rate of 1,000 barrels per day, a record for a prairie well.

With this success in hand, Imperial immediately arranged a large drilling program, and independent companies took what acreage was available. At the turn of the year 34 wells were in production, all of the major class. Of this total, 24 belonged to Imperial and 10 to independents. At the time of this review 16 more are drilling, eight by Imperial and eight by independents.

Three definite zones have been established. They are known as D1 at the top of the Devonian, not so far productive; D2 around 5,050 feet, and D3 around 5,350 feet. Production from the last two has been heavy. In those sections of the field where both zones are porous, the regulation, which permits only one well to each 40 acres, is adjusted to allow two, one to each zone. Approximately 4,000 barrels per day are now running through the pipeline.

Wells have been held down to a fraction of their potentials, which on open flow have run from 500 to 2,500 barrels per day. Production is taken through chokes varying in sizes, all of which are small fractions of an inch.

In the year since the discovery well was brought in at Leduc, new developments have continually presented themselves, each treading on the heels of the next. For tracts of land not held by Imperial there has been active bidding. The highest price to date paid by an independent company has been $200,000 cash, plus 100,000 barrels of oil, plus 12½ percent royalty for a single quarter section (160 acres). Independent companies have lost no time in drilling acreage secured as close to the proven area as possible. Five of these wells, to the east and southeast of the center of the producing field, ended in failure and were abandoned. They represent the only abandonments to date, 39 wells having been drilled in the field and 34 completed successfully.

The present estimated potential of the Leduc field is stated to be around 100,000,000, barrels from the two zones. Price of the oil has been increased twice within the past year. On July 8 Imperial set a well-head price at $2.67. On October 28 an increase of 27½ cents per barrel was made, and a second increase of fifty cents came on December 12 following an advance in United States prices. Value of the potential of the field at the present price is in the neighborhood of $345,000,000.

Leduc is already near to the area of Turner Valley and promises to exceed it. Border markers are yet to be determined. Turner Valley, however, during its 33 years of activity, has produced in excess of 92,000,000 barrels up to the end of 1947. It is expected that this famous area will appear in official production reports for many years yet, despite its annual decline.

The discovery of the Leduc oil field was made after years of survey and exploration carried out at great cost by Imperial Oil Limited. Other operators have succeeded too. The Clifton C. Cross—J. M. Dillon Group of Calgary, supervising the activities of Globe, Leduc West and East Leduc independent companies, have yet to experience a failure.

On three occasions they have extended the proven area of the field. Globe and Leduc West, operating together, brought in their first well in August, a mile and a half to the northwest of the then proven ground. In October the same team brought in its second well two and a half miles to the west of this area, and in November East Leduc brought in its first well three-quarters of a mile to the south of that area. In addition to the six big producers now located in the north, west and south of the field, new wells of this group are now being drilled.

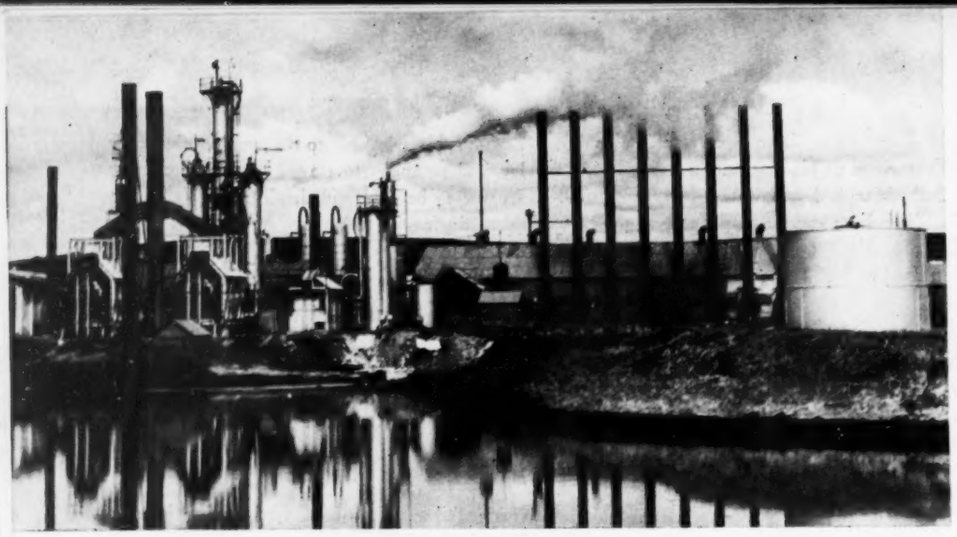
Five wells have been completed on a 480-acre tract of Hudson's Bay Oil and Gas Company. Latest additions have been Leduc 30 on acreage held by Hudson's Bay Oil and Gas and Imperial Oil Ltd., which was completed in the Devonian at 5,324 feet for 1,560 barrels daily, and Leduc 32, bottomed at 5,327 feet for 1,052 barrels daily.

The fifth and among the most important of the extensions was made by Imperial with its Woodbend well, the first north of the Saskatchewan River, two and a half miles to the north and one and a half miles to the west of the Leduc West producers in the previous northern limit of the field. It came in as another major well. Classifying Woodbend as an extension, the proven area of the field is now seven miles from north to south and four and a half miles from east to west.

Progress of the 1,200 mile exploration area of Lloydminster during 1947 was noteworthy. Total production from the various pools operating there for the year—that is to say in the combined area on both sides of the Alberta-Saskatchewan provincial boundary line—came to 845,863 barrels. This figure is approximately four times the total for the previous year.

Cumulative total for the combined area from 1939 to 1947 inclusive is 1,115,898 barrels. Wells completed in 1947 totaled 177 to compare with 58 in the previous year. Footage drilled in 1947 came to 346,502 as against 111,314 for 1946. An annual total very much in excess of a million barrels is expected for the combined area by the end of the present year.

On the Alberta side is the Lloydminster (Al-



Gas and Oil Refineries Ltd. refinery in Turner Valley

Pipeline to Leduc field crossing a 150-foot-deep ravine by suspension bridge.

berta) pool adjoining the town, Blackfoot, about six miles to the southwest, and Dina about 18 miles straight south. On the Saskatchewan side is the Lloydminster (Saskatchewan) pool and Lone Rock, some 20 miles to the southeast. Production in 1947 on the Saskatchewan side exceeded the Alberta side by 223,919 barrels.

The product of this area is a heavy crude oil ranging in gravity from 10 to 20 degrees API. Production depths average around 2,000 feet in Cretaceous sand above the Devonian limestone. The lower price for this oil in comparison with higher gravities is compensated for by the considerable saving in drilling costs. A well can be completed in a few days.

Major companies to enter the field were Continental Oil Company, then Husky Oil and Refining Company and Imperial Oil. Discovery of the field was made in 1934, but no production is recorded until 1939. In 1944 the first good well came in and the year closed with a production of 6,296 barrels from 12 wells. These figures refer only to the Alberta side of the field.

The Husky Oil and Refining Company moved its refinery from Cody, Wyoming, last July. It has a present throughput of 2,500 barrels daily to be stepped up later to 7,500 to coincide with increasing production and market. There are two plants in Lloydminster, the second being Excelsior Refineries, Limited, which opened in 1944. Its present throughput is 1,200 barrels daily with maximum capacity of 1,800.

Asphalt, of a very high analysis, together with fuel, diesel and furnace oils represent main by-products of the area.

Production from the smaller Alberta fields during the first eleven months of 1946 and 1947 has been as shown in Table III.

It will be noted that with the exception of Princess and in a lesser degree Del Bonita, there is little change in the other Alberta fields. Wainwright shows a small increase, but that field has changed very little in annual totals during recent years. The upward trend at Princess, however, is definitely encouraging as pointing to continuing enlargement.

Table III

Oil Production from Other Alberta Fields

(Quantities in barrels of 35 imperial gallons)

Field	1946	1947	Changes
Taber	189,702	187,517	— 2,185
Conrad	197,769	186,230	—11,539
Princess	59,320	91,177	+31,857
Vermilion	169,412	128,058	—41,354
Wainwright	14,163	16,890	+ 2,727
Jumping Pound	3,607	2,480	— 1,127
Del Bonita	2,064	4,312	+ 2,248
Provost	—	115	+ 115
Red Coulee	1,140	—	— 1,140
Totals	637,177	616,779	—20,398

Operations of the Shell Company in Alberta have been carried out in the Jumping Pound area some 40 miles northwest of Calgary. Test wells there have drilled to considerable depths. Gas pressures have been heavy, and the area will no doubt have a definite place in the line-up of natural gas reserves in Alberta if exportation from the province is permitted.

At the close of the year two more oil discoveries were made in Alberta—the first at Bantry some twelve miles to the southwest of Princess, and the second at Pincher Creek in the southern part of the province.

The Bantry well, completed early in November, was drilled by the California Standard and Imperial Oil companies. Oil in heavy volume flowed from a Cretaceous sand at 3,249-50 feet. Drilling continued to 4,824 feet in the Devonian. The hole was then plugged back to the Madison lime and seven-inch casing was set at 3,316 feet to be perforated opposite the porous section of the oil sand. Gravity of the oil was stated to be 24° API. Flow and pressure tests were then undertaken before information regarding production was released. Location for a second well has been staked.

After several years of exploration by different companies at Pincher Creek in Southern Alberta, an interesting development was reported in December. The Canadian Gulf Company, drilling its Gulf Pincher Creek No. 1 well, ran a drill-stem test at 11,718 feet. A heavy pressure was built up, and after blowing out a water cushion of 3,500 feet which had been run into the well as a protective measure, there followed a flow of 10,000,000 cubic feet of wet gas per day. There was also evidence of light crude oil around 50° gravity.

After shutting in the well for seven minutes, pressure was built up to 5,775 pounds, one of the highest ever recorded in the province. The two discovery wells of these different areas point to the possibility of two important new oil fields in the province.

Albert's natural gas reserves, so plentiful and with enormous potentials, have been for many years more or less forgotten quantities. Three fields only are in operation for the purpose of serving the province with heat and fuel for domestic and industrial use. They are the Viking-Kinsella area serving Edmonton and northern towns, Turner Valley serving Calgary and the south, and Medicine Hat-Redcliff, oldest field of all, serving its immediate area.

Added to these developed gas areas are semi-proven ones such as Jumping Pound, Pakowki and Princess-Steveville in the south with Peace River, Pouce Coupe, Pelican Rapids and others in the north. Natural gas with varying pressures may be obtained almost anywhere in southern Alberta and in many other parts of the province.

A four-man commission, composed of two federal government officials and two Albertans representing the province, is making a survey of Alberta's natural gas reserves with a view to the possibility of shipment of the product to other Canadian provinces. Financial groups are making tentative plans on the possibility of such shipments. One suggestion is for a pipeline east to Winnipeg, and another for one west, following an American route down the Columbia River, then swinging north into Canada again and finishing at Vancouver. Approximate cost of the eastern line is said to be placed at $45,000,000 and of the western one at $80,000,000.

The following tables have just been issued by the Dominion Bureau of Statistics at Ottawa covering oil and natural gas production by provinces in Canada. Figures for 1946 are final and for 1947 preliminary.

Extraction plant adjacent to Turner Valley townsite in the center of the field.

Oil Production In Canada by Provinces

(Quantities in barrels of 35 Imperial gallons)

Province	1946 Final	1947 Preliminary
New Brunswick	28,584	22,848
Ontario	123,082	124,954
Saskatchewan	116,686	528,932
Alberta	7,137,693	6,711,276
Northwest Territories	177,282	244,194
Totals	7,583,327	7,632,204

Natural Gas Production In Canada by Provinces

(Quantities in M Cubic Feet)

Province	1946 Final	1947 Preliminary
New Brunswick	541,010	465,259
Ontario	7,051,309	7,581,715
Saskatchewan	209,569	172,047
Alberta	40,097,096	45,089,861
Northwest Territories	1,500	1,500
Totals	47,900,484	53,310,382

It will be seen by this table that Saskatchewan with an increase around 400,000 barrels and the Northwest Territories with about 67,000 barrels are the reasons which make it possible for 1947 to show an advance of some 50,000 barrels. Alberta unquestionably will show an outstanding increase by the close of 1948.

Norman Wells in the Northwest Territories produced from about 45 wells during the war. The product was transported by pipeline to Whitehorse to the refinery there. It was a war measure, however. The Japs were menacing the Aleutians and coastal passage for tankers was hazardous. When hostilities came to an end, oil production at Norman Wells was reduced to quantities sufficient only for needs of the adjacent area. To operate the field at capacity in peacetime was definitely uneconomic.

Just after the turn of the year an oil discovery was reported from Staples, Essex County, about thirty miles east of Windsor, Ontario. The discovery well came in at 1,169 feet with a force that lifted tools from the hole. Gas flow was reported at 300,000 cubic feet per day in the preliminary test. Six barrels per day of crude oil with a gravity of 38° worth $3.20 per barrel are being recovered. An oil field of about 200 acres has been indicated as possible according to Imperial Oil Limited, the discoverer.

The bright side of Canada's oil picture today is Alberta. The brightest part in Alberta is the Leduc fields, Lloydminster's great advance, the intensive exploration everywhere and new discoveries made at the beginning of the present year.

The new Leduc field is at present the greatest acquisition. Five times has it been extended in size. There may be a sixth extension shortly.

The Leduc field now has a townsite by name of Devon. Demands by workers for houses therein exceed the present ability to produce in all cases. The work is being rushed through, and a community, modern in every respect, should be established this year. All facilities will be installed—water, electric light, gas, school, movie theatre, roominghouse—with picturesque river scenery adjoining.

There are problems, however, to face. A brief has been submitted by the Western Canada Petroleum Association dealing with the acute casing and tubing shortage confronting the industry. The brief has been sent to the Dominion government at Ottawa. Plans are under way for doubling Alberta's drilling program this year, but advices from some of the mills referring to a 35 percent decrease in deliveries constitute a most serious problem.

If Alberta is to succeed in the big job of settling Canada's oil shortage situation, there must be increases in equipment. The government has stated that it is aware of this grave problem and will endeavor to aid in its solution.

Another problem, and one of some magnitude, is Canada's oil shortage—a world problem now. In the period from January 1 to October 31, 1947, the Dominion Bureau of Statistics at Ottawa revealed that Canada produced only 7.2 percent of its oil requirements. The balance had to be imported, 56.6 percent from the United States and 36.2 percent from other parts of the Western Hemisphere. Because of the shortage in the United States some fear of an embargo has been expressed. It is generally conceded, however, that existing agreements between the United States and Canada would rule out any embargo against the latter country. Imports from the rest of the Western Hemisphere might be increased, but two obstacles might prevent this. There is a shortage of sea-going tankers; the possibility exists that other Western Hemisphere countries might not be able to continue exports for long on the present scale due to domestic demands upon them.

In the period quoted above from the Bureau of Statistics covering Canada's oil requirements, the total oil consumption within the Dominion was given at 78,255,000 barrels. This total was made up as follows:

United States crude oil	41.3%	56.6%
United States refined products	15.3%	
South American, West Indian and Mexican crude oil	33.5%	36.2%
South American, West Indian and Mexican refined products	2.7%	
Canadian crude oil	7.2%	7.2%

A total well in excess of $200,000,000 left Canada in this ten-month period to pay for these imports. In view of the world oil situation the discovery and development of new and prolific fields in Canada becomes of greater importance than ever before.

Dr. A. I. Leverson, retiring president of the Geological Society of America, at a convention of the Society held in Ottawa in December, gave an interview to the press regarding the potentialities of Alberta, the oil, natural gas, bituminous sands and coal province of Canada.

He gave it as his opinion that Alberta may be sitting above pools "a dozen times as large" as those in the rich Oklahoma fields. The discovery of the Leduc field, he said, gave clear indication of "vast new possibilities in Alberta and Western Canada." He continued by saying that the seepages, asphalt and tar deposits resemble those in other areas "which account for a substantial percentage of the world's oil fields" and that it was inconceivable in this area of Alberta that there are not "hundreds upon hundreds of oil fields yet to be discovered. Not until thousands of additional test wells have been drilled throughout the region can we say that the exploration of these areas has been completed."

TOOL OF AERIAL EXPLORATION

By HOMER JENSEN*

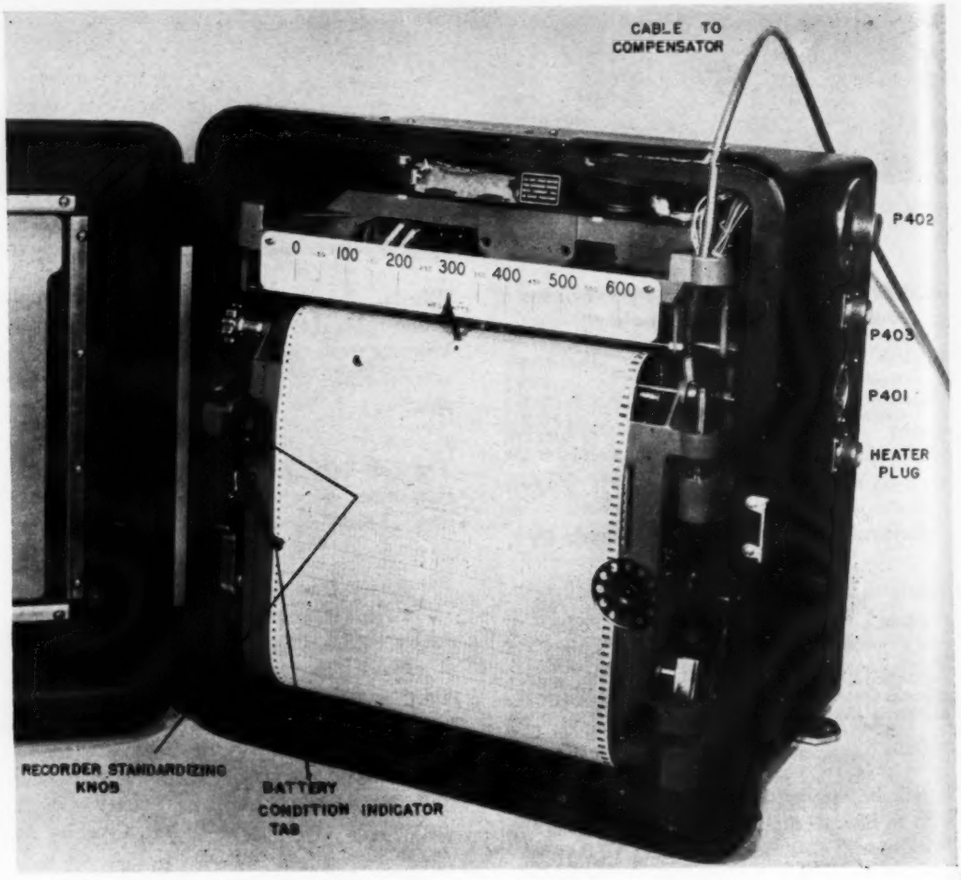
IN May, 1947, the Bahamas survey plane took off from Oakes Field, Nassau, to a large-scale regional airborne magnetometer survey. Flying was completed in seven months. This month Aero Service Corporation is delivering completed maps covering the 85,000-square-mile-area to the five major oil companies for whom the study was made.

These companies are Anglo-Bahamian Oil, Ltd. (Anglo-Iranian Oil Co.); Bahamas Exploration Company, Ltd. (Gulf Oil Corp.); Bahamas Oil Company, Ltd. (Superior Oil Co.); Shell Company of Bahamas, Ltd. (Shell Oil Co.), and Standard Oil Company, (Bahamas) Ltd. Standard Oil Co., N. J.). The survey was made with the airborne magnetometer developed by the Gulf Research and Development Company.

This year marks the second year of the airborne magnetometer's operation in commercial surveys for oil and ore. Actually Aero's experience with this important new geophysical tool dates back to 1943, when the company first began to work with the U. S. Navy and U. S. Geological Survey in the early applications of the instrument to subsurface explorations.

Today the operational techniques of this primary reconnaissance tool are well established. The airborne magnetometer's utility has been defined, and it has surveyed over all types of terrain, from the rugged, glaciated cover of the Canadian Shield to the vast expanses of shoal water in the Bahamas. It has performed smoothly at —30 or —40 degrees, and it has stood up equally well under tropic humidity. Successful airborne magnetometer surveys have been completed in Alaska, Canada, nearly a dozen of the United States, Mexico, the Caribbean and South America. About one quarter million square miles of the earth's surface now have been mapped.

The Bahamas survey, which encompassed an area greater than the state of Kansas, is in itself sufficiently large to delineate most of the problems and procedures involved in the use of this new addition to the geophysicists' exploration tools. This operation was carried out with an especially modified DC-3 and approximately 60 members of the survey party, which included pilots, aircraft mechanics, electronics engineers and technicians, Shoran operators, four boat crews, draftsmen and native personnel. Of these men, approximately half were provided by Offshore Navigation, Inc., which operated the boats and the mobile Shoran stations.



Closeup of magnetometer recorder.

Head unit of Gulf Research & Development Co. airborne magnetometer.

* Chief, Magnetometer Division, Aero Service Company.

Such surveys as the Bahamas break down into three major phases: (1) planning and staging the operation; (2) flying the survey, and (3) translating the data.

Planning of the operation started soon after the preliminary discussions with the participating oil companies, and the developing plan became the nucleus of the discussions. Decisions were reached on line separation, flight altitude, positional tolerances, sensitivity and stability requirements of the magnetometer and so on. Then a general plan of operations, incorporating these specifications, was formulated and approved by the participants. Included in the plan was a technical committee of representatives of the exploration companies to coordinate the operation.

Staging the operation first concerned itself with assembling the highly specialized personnel needed to carry out the survey with maximum speed and efficiency. More men were added to our ordinary survey complement for the same reasons that we used two flight crews instead of one—fixed overhead costs on an operation of this size are necessarily high, and speed is the keynote. The whole tempo of the survey must be geared to the swift schedules implicit in aerial survey work.

Secondly the staging involved acquisition of electronic equipment of all sorts, most of it in the war surplus markets. Had the survey equipment been produced for normal, peacetime markets and bought at the full market price, costs of some items would have been 20 times as great. We did a lot of hunting within a very short period of time and made some ingenious adaptations of wartime materials to our requirements.

Duplicate spare parts, and in some cases triplicate spares, were sent down to Nassau. Equipment failures or breakdowns can be very costly in lost time. If any piece of equipment was not up to par during the survey, we were able to replace it immediately. Furthermore a second DC-3 was held in a stand-by status in Philadelphia during the course of the survey.

Having our men and equipment in hand, we worked on such on-the-scene problems as arranging for radio frequencies, office equipment, housing facilities, transportation and customs clearances. The assistant project manager went on to Nassau in advance of the survey party to set up these important details.

Ordinarily we use existing maps and charts in flying surveys. Our preliminary checks quickly revealed that the Bahamas maps were totally inadequate. They are old and inaccurate. Since the magnetic intensity maps must be precisely related to geodetic positions, we could not use them. Shoran was our answer. More later about its use.

Fortunately good airport facilities were available at Oakes Field, Nassau. Here we based the survey plane and party; here we performed our refueling and maintenance. Incidentally, in the course of flying this survey, the DC-3 ate up over 100,000 gallons of aviation gasoline.

Left to right: Robert Singleton, project engineer for the Bahamas survey, checking survey progress with his assistant, Vernon F. Reynolds.

Some of our men and equipment flew down with the survey plane, the rest of the party coming via commercial airlines. Within a couple of weeks our routines were set up, the schedule and pattern of the project blocked out in broad terms, and we were ready to go with the operational part of the survey.

Phase II of the survey involved planning and logistics similar to the mounting and carrying through of a complex military operation. We had to learn the answers to such questions as weather, communications, positioning, supplies and all the points which are part of any large exploration job. Weather, for example, was a prime consideration in our whole activity. Therefore, we arranged for daily reports from the Miami weather bureau, giving us early morning forecasts for the general area. In addition we received hourly meteorological reports from Oakes Field.

We contributed to the collection of weather data ourselves by periodic reports from the Shoran boats to the Oakes Field weather station, and our survey plane reported promptly any unusual weather conditions it encountered. This contact between our people and the meteorological personnel had a double benefit. First we were able to take maximum advantage of all flying weather. During the latter part of the survey, for instance, we flew every day for 60 consecutive days. Secondly we were able to anticipate unfavorable weather and move our plane from the survey area in advance of the several hurricanes there this past year. Similar planning put the Shoran boats into safe water away from the hurricane hazards.

Communications were most important. Our radio network was a vital link in the survey's operation, and we had receiving-transmitting stations aboard the survey plane, on all four Shoran boats and at the survey offices at Oakes Field. All elements of the survey were in constant touch with one another. This meant that weather information could be passed on quickly, survey boats moved readily to new stations and the whole project kept on schedule. If the plane needed some maintenance attention during the noon interval between flights, it could radio word into us an hour or two in advance so that the mechanics were all set up to handle the job when the plane came in. If one of the survey boats wanted to relieve its crew, it could be arranged quickly and easily. In the day to day operation of the survey, the radio network was an absolute necessity.

Before the survey plane could begin its first day's mapping, we had to work out a flight plan for the whole area. We had to know where we were going, not only from day to day, but on a month-to-month basis.

Often surveys over land areas are done "contact." The pilot or copilot follows the course on a flight map or aerial photos. This sort of survey involves flying a series of parallel flight lines by visual reference to maps or photomosaics.

But the Bahamas problem was quite a different one. Only 10 percent of the entire area is land. Over large areas of the concession the islands cannot be seen even from an airplane, so the pilot could not orient himself by visual reference. Finally, existing charts were hopelessly inaccurate.

We, therefore, turned to another wartime device. We used Shoran to guide the survey plane over the entire 85,000 square miles, mak-

ing the survey one of the largest single Shoran-directed jobs ever done.

Certain primary geodetic control points in the Bahamas area had been established by the U. S. Army and the Hydrographic Office of the Navy. From these we surveyed in our own control points. Usually these were mobile Shoran stations, aboard boats which were anchored in pairs about 30 miles apart, but one Shoran ground station was set up atop the water tower at Nassau, highest point available in the area.

Shoran operates only on a line-of-sight range, and in our case satisfactory Shoran contact could be maintained only for a distance of roughly 42 miles.

The Shoran boats assumed approximate positions by dead reckoning. Then anchored, and their positions were triangulated in precisely by Shoran, with the survey plane making the measurements. The boats then served as fixed points for the surveying of that area.

One of the pairs of Shoran boats is known as the drift station, for in effect the survey plane drifts around this station in a constant radius for each traverse, until it reaches the 42-mile limits of the Shoran transponder. The second boat, known as the rate station, completes the triangulation system. The distance from the plane to the rate station is a constantly changing one; at each integral mile a fiducial or reference marker is tripped, recording simultaneously on all records.

The records made in the plane consisted, besides complete log books, of (a) the magnetometer tape, (b) a record of deviations from the nominal drift arc, (c) a radio-Altimeter record. Through the fiducial system the records were correlated each mile, and it was thus possible by interpolation to relate the magnetic record continuously with the chart of position to tolerances of about plus or minus 150 feet horizontally and 25 feet vertically.

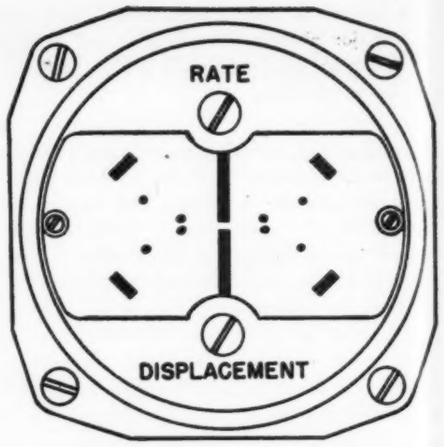
Planning the day-to-day operating positions of the boats was carried out on a map of the survey area at a scale of one inch: 8 miles. The project engineer made up the daily flight from this planning map, the boats moving so that one crescent after another was mapped until the whole area was finally covered. Each day's flight plan was worked out in detail and run off with enough copies to inform all parties involved.

Shoran operated the pilot direction indicator, which constantly showed the pilot whether he was "on the line" at the precise moment and whether continuing his general line of flight would keep him on the line. When both markers or indicators of the PDI pointed straight up and down, everything was fine; deviations from this position reflected deviations from the "on the line" position.

In general the flight was made within 150 feet of the indicated path, and the continuous flight record permitted correction even in the few cases where this limit was exceeded.

Flying the PDI was much like flying an instrument landing system all day long, the survey pilots said. It takes concentration, and lots of it. In fact such flying is done by airline pilots only for a matter of a few minutes at a time when landing in dirty weather.

From the pilot's standpoint, the Bahamas survey could have been flown almost as well at night, since they were on instruments during the whole time on survey lines. For this reason weather was minimized as a factor, except that heavy rains or excessive turbulence could stop operations.



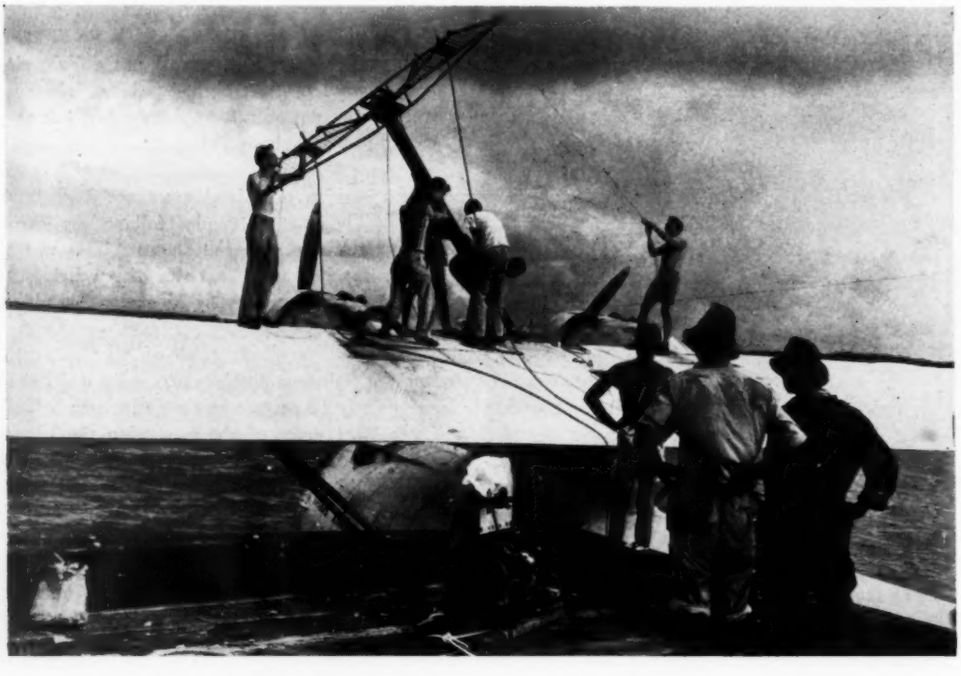
PDI, or Pilot Direction Indicator, used in the survey for plane positioning. The displacement marker or needle tells the pilot whether he is on course. The rate marker indicates whether his heading is correct to remain on course. The markers are shown in the "on course" position in the above diagram.

Local, brief thunderstorms were frequent, and the year 1947 saw the worst rain and hurricane season in many years, according to Bahaman observers. The high humidity was always with us, and it called for constant maintenance of the electronic equipment. The salt air made necessary daily oiling of the propellers and wiping down of the plane's surfaces to avoid corrosion. The salt air and humidity were often evidenced by a haze of salt which formed on the plane's windshield during a single morning's flight.

Dawn take-offs were standard operating procedures, which means that by 6:00 on most mornings the pilot was running up his engines and performing the usual preflight procedures before take-off. At the same time the electronic staff made preflight checks on the magnetometer and Shoran; and the project engineer called the Shoran boats to give them their schedule. The magnetometer and Shoran transmitter were warmed up, the recording instruments loaded with paper and ink. By daybreak the DC-3 was winging to the survey area for the day. That area might be as close as 40 miles or as far as 250. At about 50 miles the Shoran operator picked up the mark-ships on his 'scope. Over the intercom, he would call off the distances to the boats for the pilot, and then at a distance of a half-mile begin to "talk the pilot on to the flight line." In rapid-fire chatter back and forth, he and the pilot would pin down the plane's course until the pilot had brought the plane within 600 feet of the line and the DPI would take over.

This first flight of the day lasted about six to seven hours, at an average speed of 160 miles per hour. About noon the DC-3 returned to Oakes Field to be refueled and checked over by the ground crew. Within the hour a new flight crew was in the air again, and the flying went on for another six hours or so. Often the day's flying ended with the last daylight hours, the plane flying back at dusk or early evening.

A Shoran mast was erected aboard a BPY plane as one of the stations for the Bahamas survey.



Of course, so intense a schedule could not be maintained day after day. Equipment failure or personnel limitations caused single-flight days and some days of no operations.

We set up a data reduction unit at Nassau made up of about eight men. The tapes from the magnetometer recorder were delivered to the unit at the end of each flight, along with the radio altimeter tape and the PDI tape. These were recorded and indexed; and the correlation of magnetic control information with ground position was completed as soon as possible.

At first we tried to reduce most of the data in the field, but it proved impractical to do so with the staff available; we, therefore, accumulated data and then reduced it in intense operations at the home office in Philadelphia. This was a departure from our original intention to reduce data almost currently with the flying, but we hope on the basis of our experience here to be able in the future to achieve that aim. Our final rate of data reduction to the form of preliminary contour maps was better than one thousand square miles per day.

An important aspect of the use of Shoran is that it tremendously simplifies the problem of data reduction. We built special data plotting tables which enable us to construct accurate models of two or three thousand square miles of survey at a scale of one inch to the mile in a matter of a few minutes. On these models we would plot magnetic values corrected against drift and diurnal variations and regionally adjusted.

Our survey pattern was devised to give us control over all drift factors, but we operated a base magnetometer at Nassau during the survey, as a sort of "watch dog" to enable us to stop operations on magnetically unsatisfactory days. We made no attempt to apply corrections from the base station to our airborne record. To our surprise, we did not have to stop operations for magnetic storms even once during the whole seven months of the survey.

In preparing a magnetic map for a survey done by contact flying, essentially the same steps would be followed, with one change. In this case the images on the Sonne continuous strip film (which photographs the plane's flight path) are identified on the base map for the area. The strip photos are already correlated with the altimeter tape and the magnetometer recorder tape by identical fiducial marks.

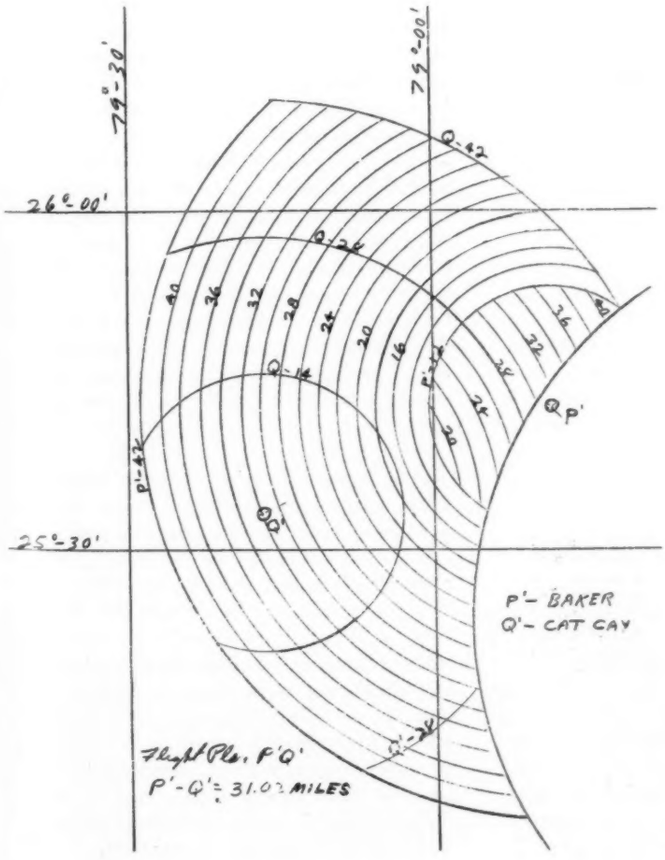
It has been Aero's attitude that we are simply collecting data accurately and carefully and assembling it in a precise map presentation for study by petroleum geologists and geophysicists.

The data obtained from the magnetometer survey is reduced to map form without inflection or emphasis. It is not our function to edit or weight the data obtained. We feel that only through such straightforward data reduction can the geophysicist approach the finished maps with full confidence that he has at hand all of the facts for evaluation. The results of the Bahamas survey will have immediate utility as a guide in planning further exploration with more precise geophysical tools and also as an aid in planning policy as regards concession renewal. It will be years, of course, before the whole exploration program of the area has progressed far enough to permit a final evaluation of the results.

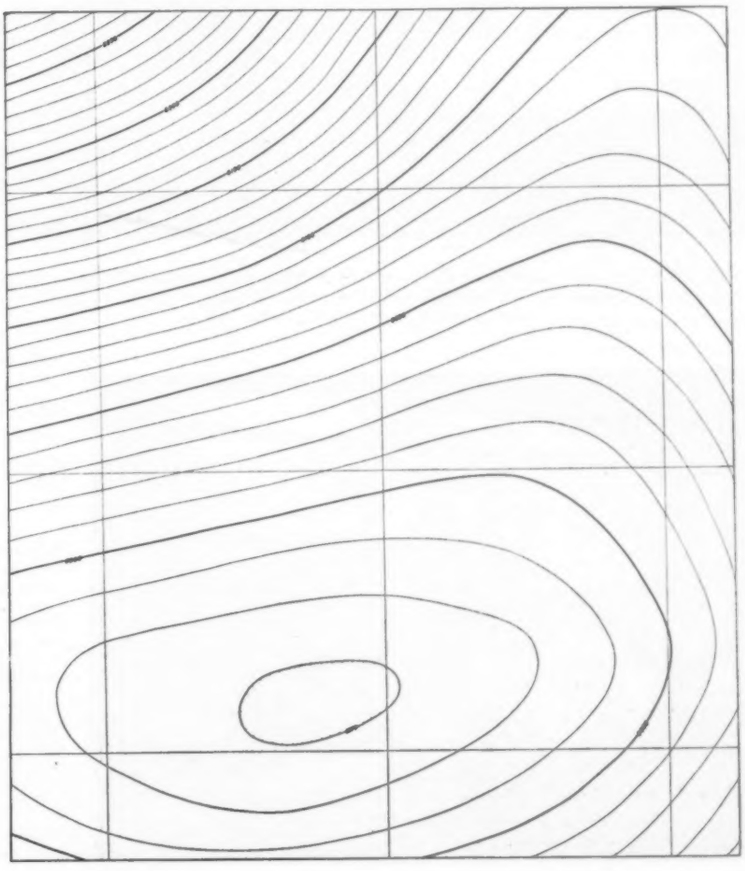
These Bahamas maps, the product of 1,000 hours of flying and over 20,000 manhours of data reduction, are material evidence that the airborne magnetometer has come of age as a primary reconnaissance tool. The oil companies can now order such surveys to rigid specifications, anywhere in the world. Maps accurate to a few gamma can be delivered promptly for their further exploration study.

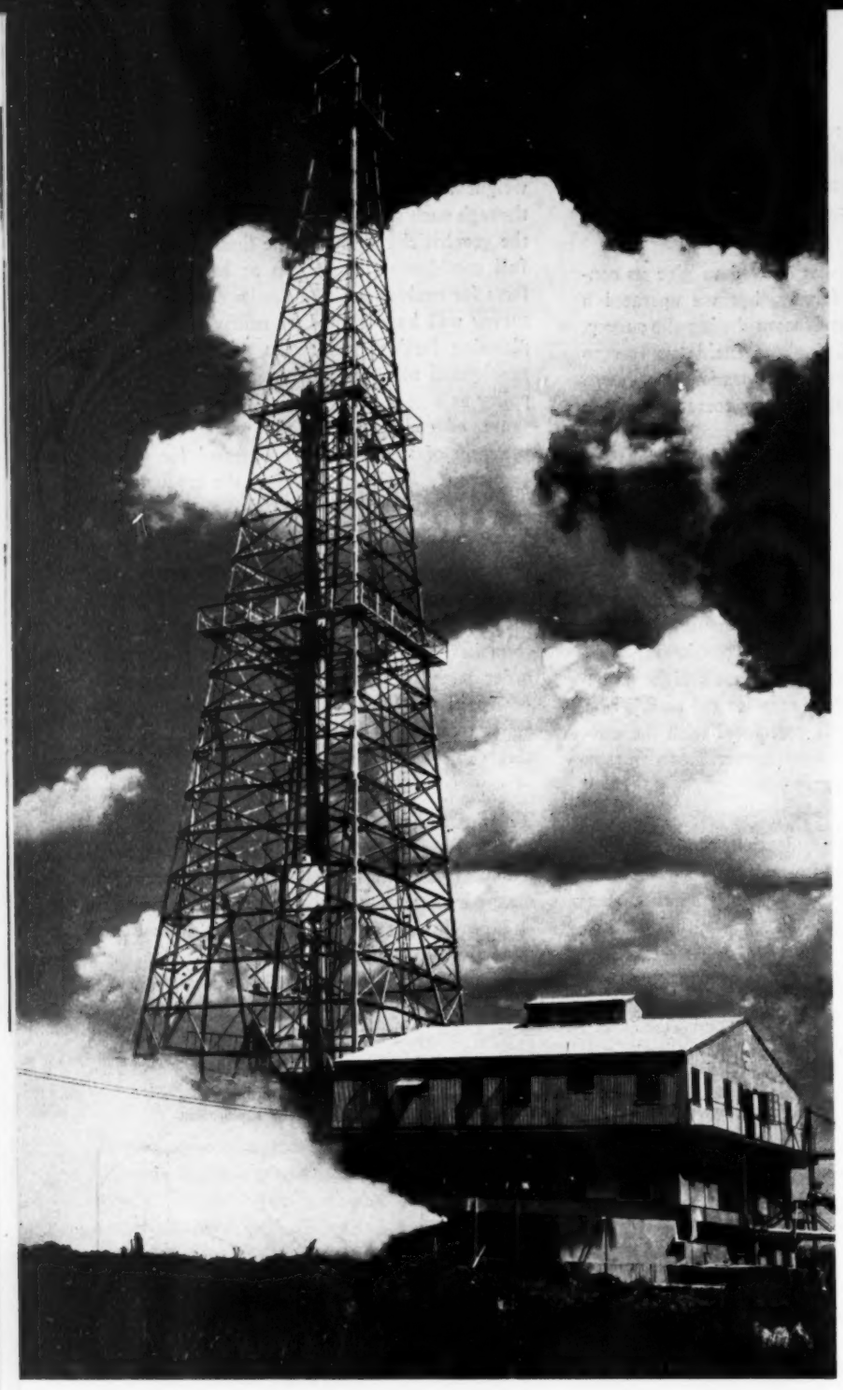
This instrument is no magic tool. For preliminary survey work, however, the airborne magnetometer combines speed with a new accuracy in magnetic measurements. The petroleum geologist and geophysicist are the men who must determine the value of such regional studies to their continuing search for new oil resources.

Flight plan for one part of the Bahamas survey.



Representative section of a magnetic intensity map made during a survey for oil. This map was not made in the Bahamas exploration.





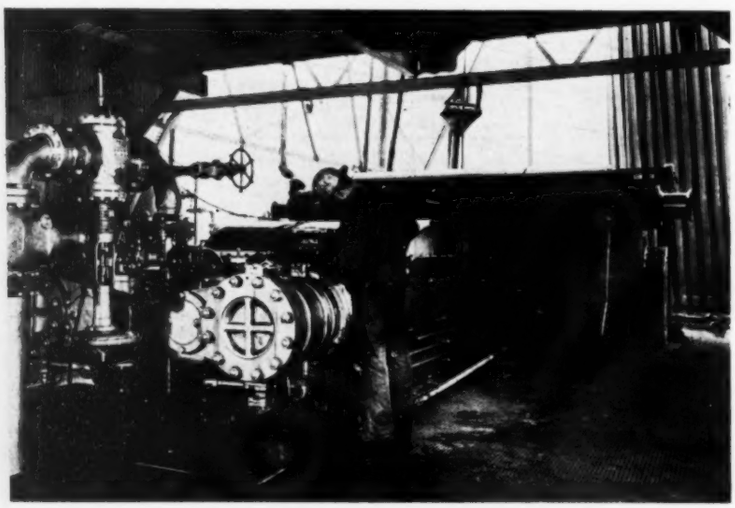
Shell Oil Company's new drilling rig is the largest, tallest and most powerful steam rig yet built. It is designed to drill to 18,000 feet. The rig-mounted barge with its 1,984,000-pound loaded weight draws only 4½ feet of water.

Traveling block on the Shell rig weighs 19,000 pounds. The rig handles 135-foot triple stands of 5-inch pipe and has a working capacity of 950,000 pounds. Photographs on this page are from the Shell Photo Library.

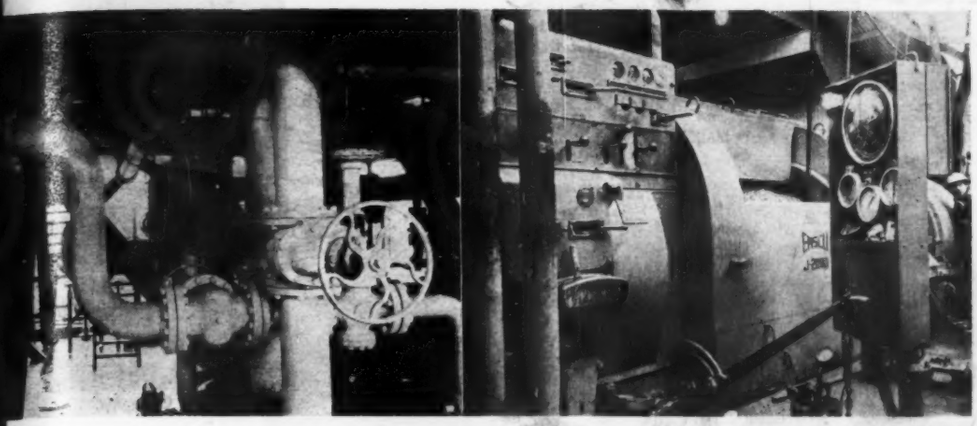
WORLD'S LARGEST BARGE-MOUNTED DRILLING RIG

LARGEST of its kind in the world, designed to probe the earth's surface to a depth of 18,000 feet and provided with powerful equipment and the latest of control devices, Marine Rig No. 7 of Shell Oil Company is now in operation in the swamplands of southern Louisiana. Mounted on a single-hull barge, the biggest yet built for such service, the outfit is a mobile unit capable of being moved from one location to another in the shallow-water area. At last report it was down to 11,957 feet on its second well, Smith-State Unit B No. 2, in the Weeks Island field, in Iberia Parish, Louisiana. It is rated the largest rig ever assembled in several particulars, including horsepower developed, engines, mud pumps, Range 3 drill pipe and size of derrick.

The derrick structure is 185 feet in height and, when mounted on the barge, towers 225 feet above the surface. It has a 952,000-pound API rating. Its base is 40 feet square, and it has a clearance of six feet eight inches in the crown. There is a clearance of 31 feet in the "V," and it has a 15-foot, 15-ton capacity gin pole. The entire structure including the floor beams is galvanized to prevent corrosion in the coastal atmosphere. Girts to support thribble boards are provided for either Range 2 or Range 3 drill pipe, and a safety platform is provided at each position. The 15-foot substructure, of special design, is welded directly to the barge. Each substructure leg is capable of supporting 300,000



Engine room on the barge is equipped with a 1,790 BHP steam engine to actuate the Emsco J-2000 drawworks. The drawworks has a theoretical load capacity of 30,000 feet of 4½-inch drill pipe weighing 510,000 pounds.



Left: Piping below the rig floor. Right: Driller's controls. To coordinate crew activity he has an intercommunications system enabling him to talk with the fireman, engineer, and derrick men at the crown and on monkey boards.

pounds. The 36-inch, 236-pound beams which support the rotary are designed for a load of 700,000 pounds of drill pipe.

Source of steam power consists of five 150-horsepower Farrar & Trefts oilfield boilers mounted on a separate 100 x 34 x 16-foot deep submersible barge which rests on bottom while in operation the same as the drilling barge. Based on a 300 percent rating, 2,250 horsepower is available for peak operations. Space has been provided for a sixth boiler which would increase the horsepower available to 2,700.

Central feature of the outfit, likewise of record size, is the Emsco Type J-2000 drawworks, which is rated at 2,000 horsepower input and has four speeds. The wire rope drum is 34 inches in diameter by 60 inches long with brake rims 60 inches in diameter. By reason of having an intermediate transmission, it may be used with steam engine, mechanical power or electric motor drive. It is presently powered by a 16 x 16-inch twin cylinder horizontal steam engine having a rating of 1,790 brake horsepower at 350 rpm, when using saturated steam at 350 psi. All clutches are pneumatic and an air-actuated Leslie steam throttle valve controls the amount of steam going to the engine. A control panel mounted at the driller's side of the drawworks includes air valves which are used to actuate throttle valves on the mud pumps and rotary engine as well as the drawworks engine; other air controls are used to change the hoisting speeds and to engage and disengage clutches on catheads. An eddy current Dynamatic brake is used to control the fall of the drill pipe when round trips are being made. It operates on the principle of eddy currents which are created when the shaft connected to the drawworks turns inside an electrical field. The pipe can be slowed down until it barely moves while the air-operated slips are being set.

The rotary table is driven separately by an Ideal 12 x 12-inch steam engine located under the derrick floor and connected to the rotary table through a special jack shaft which has a cat head and special brake drum for stopping the rotary. This engine also has an air-actuated throttle valve to control the amount of steam going to the engine.

Two 19 x 7¾ x 22-inch Ideal mud pumps are used to circulate the drilling mud. Each of these pumps requires approximately 1,000 horsepower input at peak operating conditions and will develop 2,900 pounds per square inch mud pressure with 6¼-inch liners. Either pump is rated at 500 gallons per minute output at the above pressure. A 15½ x 8½ x 20-inch mud pump is used as standby transfer and circulating pump.

Rig No. 7 is equipped with 15,000 feet of five-inch O.D. Spang-Chalfant 19.40 pounds per foot internal upset drill pipe with 4½-inch internal flush tool joints. The joints of drill pipe vary from 42 to 45 feet in length (Range 3) and the height of the derrick allows 135-foot stands to be pulled in thribbles. With the tall derrick the time of round trips is greatly reduced and more time is saved for making hole.

The Byron Jackson speed trip power slips have been in use on many rigs for the past two years. Power slips make possible important savings in trip time and elimination of the back-breaking labor connected with round trips. The slips are actuated by the driller at his normal position by simply depressing the control pedals with his foot.

The coring reel of the rig is separately powered by a 9 x 8-inch horizontal steam engine and is a heavy-duty unit capable of holding 18,000 feet of ⅝-inch coring line. A cathead is connected to the drum shaft for use in light hoisting work. The drilling line is 1⅜-inch hemp center, 6 x 9 improved plow steel, having a nominal breaking strength of 155,400 pounds and was purchased in a 3,300-foot length. The crown and traveling blocks are seven sheave, 600 ton, and six sheave, 500 ton, respectively, with all sheaves 60 inches in diameter.

The drilling barge is a single hull, 152 feet long by 54 feet wide with a depth of 14 feet. The hull and superstructure weigh approximately 600 tons. When fully outfitted, the barge with equipment weighs approximately 1,000 tons not counting the drilling mud or water supply. The barge has an eight-foot slot extending 84 feet from the forward end to allow it to be moved off locations after the Christmas tree is in place. The hull is divided into six main compartments and with collision compartments in the rake of each end. The main compartments are used for submergence water to sink the barge on location. The barge is sunk to the bottom by opening sea cocks and ballast valves in various compartments and is raised by using steam jets that empty the water overboard. The hull was constructed in accordance with American Bureau of Shipping standards and was inspected and certified by that agency.

The boiler barge furnishing the steam for Rig No. 7 is 100 x 34 x 16-feet deep. To minimize the boiler water makeup, plans have been made and work is proceeding on the installation of condenser equipment. A vertical, close-coupled Pomona pump will be set over a shaft leading to the open water and will pump sea water through a 2,000 square foot condenser, and all condensate will be returned to the boiler barge. Such equipment has already been installed on other Shell marine rigs. All feed water is heated by a deaerating heater designed to heat 60,000 pounds of water per hour from 60° to 225°F. A three-inch gas regulator is used to control the natural gas supply going to the burners. The burners are forced draft, and the fan turbines are controlled by a one-inch regulator. In firing with oil a one-inch pump governor is controlled from a volume tank to maintain a constant pressure on the burner manifolds. Pumps used in the oil service are 6 x 4 x 6, and an oil heater is used to preheat the oil to any desirable temperature up to 180°F. prior to entrance into the burners. Four feedwater pumps are used on this barge, consisting of two 10 x 6 x 10-inch and two 10 x 4½ x 10-inch.

A 96-foot galvanized structural steel walkway is used between the drilling barge and the boiler barge. The walkway is hinged to the drilling barge on one end with the other end resting on the boiler barge and may be raised by a line from the derrick when changing locations. The steam and water pipes are fastened to the outside of the walkway and are insulated.

There are a number of other items that should be mentioned on this rig. An "intercom" system is being installed for communication between the driller, derrick man and boiler fireman. A slot is cut in the upper deck of the starboard or water side to allow subs, special tools and other supplies to be loaded aboard with the catline. The loading boom is a 35-foot-long, 10-ton-capacity unit which is operated by a small steam winch. The upper deck is covered by a large engine house which encloses the drawworks engine and over 1,000 square feet of office, galley, sleeping quarters and change room space. Two large supply rooms are also located on the upper deck.

The reserve mud pits beneath the pipe rack and the three operating pits on the opposite end of the barge will hold a total of 3,300 barrels of mud. The two dry mud and chemical houses located above the operating mud pits on the aft end of the barge will hold 2,000 sacks. A belt conveyor is used to relay mud from the supply barges to the drilling barge.

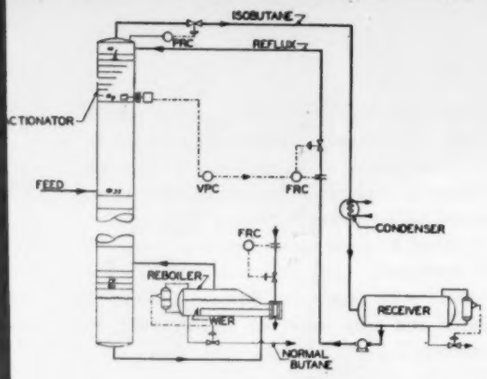


FIGURE 1

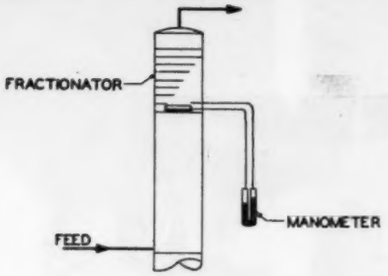


FIGURE 2

Fig. 1—Deisobutanizing column for fractionation of iso and normal butane.

Fig. 2—Vapor Pressure Balance.

Control of Narrow Boiling Range Fractionation*

G. G. Gallagher

By G. G. Gallagher

PRESENT-DAY petroleum refining practices are working toward a higher and higher degree of separation of the narrow-boiling-range hydrocarbons; hence more accurate and more direct methods of instrumentation and control are required. The usual means of temperature and pressure control, long used on ordinary fractioning columns, are not adequate for the super fractionators encountered.

Figure 1 shows a deisobutanizing column which fractionates isobutane from normal butane. At 110 psi column pressure, there is only 23°F difference between the boiling point of pure isobutane and that of pure normal butane. On this basis a change of only 1.0°F in column temperature will cause a change in composition of approximately four percent. From this it can be seen that the accuracy required is hardly possible with present-day temperature controllers. Holding the temperature alone constant will not suffice since the purity of the product overhead may also vary in the order of two to three percent with a change in pressure as small as 1.0 psi. Changes in barometric pressure alone can be responsible for variations of several percent in the purity of the overhead material. From this it can be seen that it is important to maintain both pressure and temperature within very close limits. Since temperature and pressure controllers with the required accuracy were not available, a search was made for a better method of control. What was most desired was a composition controller that would make the necessary adjustments to the process for variation in column temperature, pressure, feed composition or feed quantity.

One method which has been developed for controlling such narrow-boiling-range columns is commonly known as a vapor pressure controller, although on strictly binary columns it is essentially a composition controller. This instrument consists of a temperature bulb and pressure connection, both being located at the same point in the column. (Figures 2 and 3). The temperature bulb is partly filled with one of the materials being fractionated. This bulb, when exposed to to the column temperature, will exert a vapor pressure against one side of the diaphragm or mercury U tube, the other side of which is opposed by the pressure of the column taken at the same point that the temperature sensitive bulb is located. Whenever the material at this point in the column is of the same composition of that in the bulb, no differential on the instrument will exist regardless of what pressure or temperature elevation is encountered. Conversely, by holding a zero differential pressure on the vapor pressure controller, the composition on the tray will always be the same as that in the bulb.

By looking at curves on Figure 4 it can be seen that with a constant differential on the vapor pressure controller, very little change in composition is encountered, even with wide changes in column pressure. In other words, with a 1.0 psi change in column pressure, the composition will only change 0.4 percent instead of the two to three percent encountered when using a temperature controller and assuming it holds the temperature perfect. Therefore, it may be said that this instrument can control composition within very close limits by controlling the differential pressure between the column and the bulb.

Although this method of control is satisfactory for binary columns, its use in columns of multi-component mixtures is somewhat limited, and the limitations have not been fully explored.

The petroleum and chemical industries have developed needs for new and revolutionary type instruments faster than the instrument industry was geared to keep in step. Several years after development of the need for better means of controlling the multi-component columns, undesirable indirect methods of control were still being used because a satisfactory direct composition controller was unavailable. This is a definite challenge to the instrument industry to intensify its research and development along these lines.

* Presented before the Chicago section of the Instrument Society of America, February 3, 1947.

** Universal Oil Products Company.

Fig. 3—A vapor pressure transmitter.

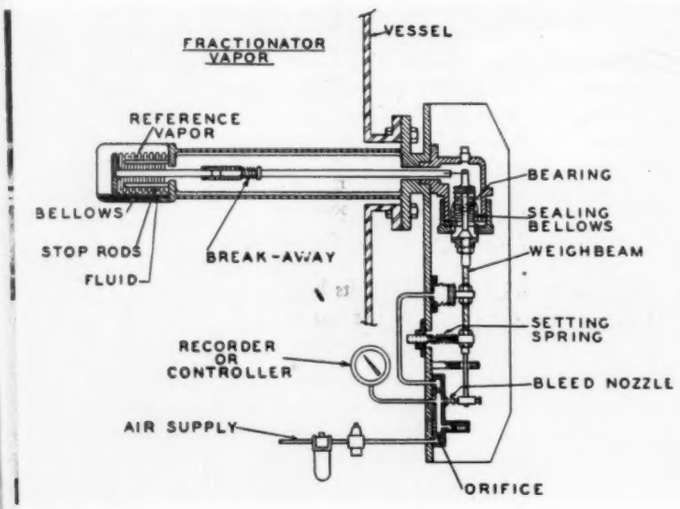
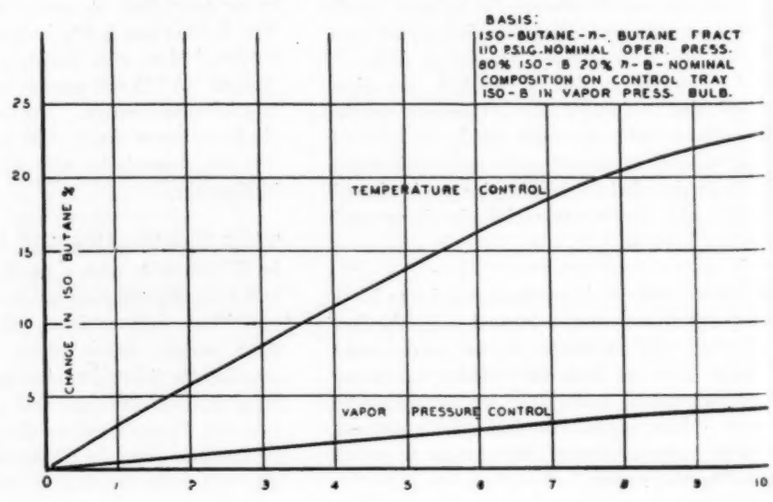
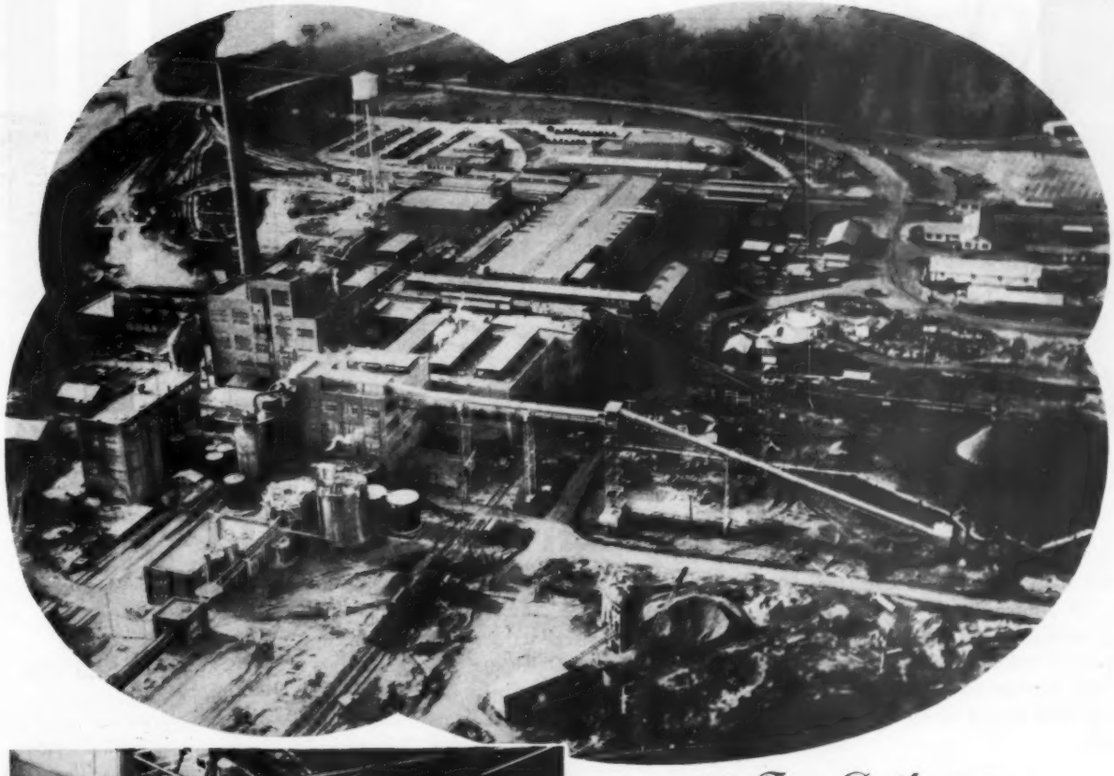
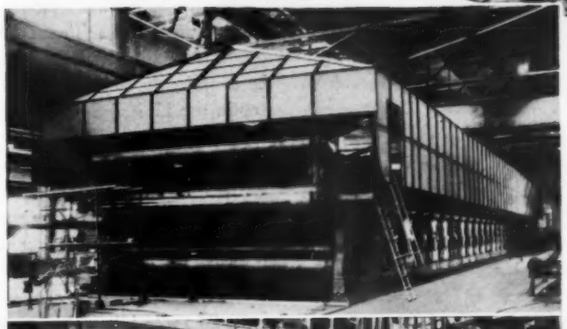
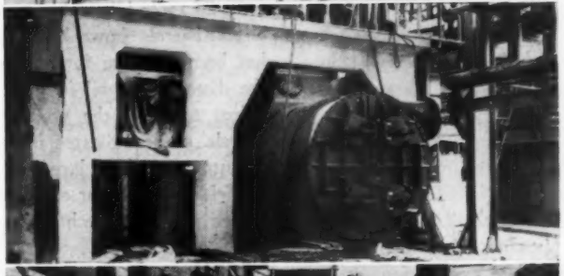


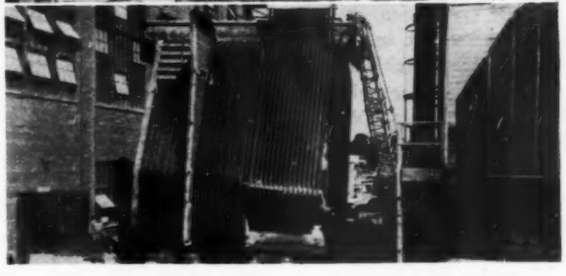
Fig. 4—Composition change on control tray vs column pressure deviation for binary column using vapor pressure controller or temperature controller.











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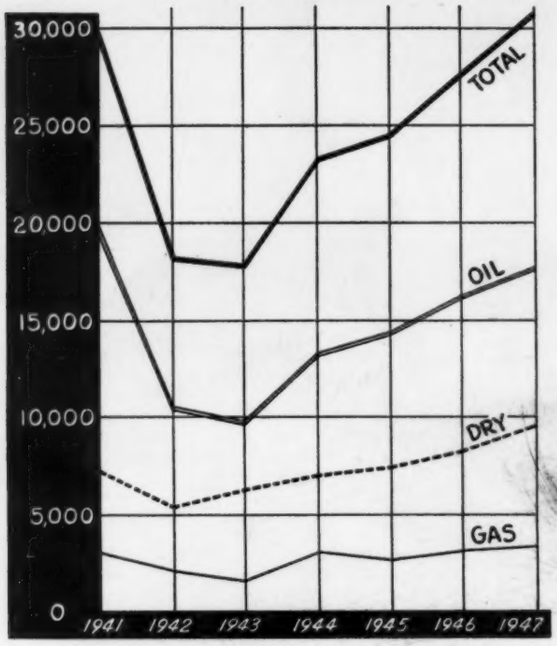
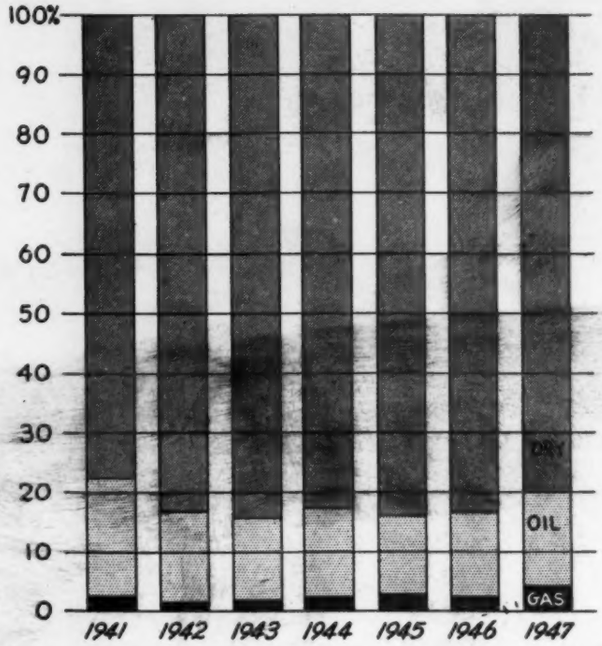


Trend of drilling operations in the United States.



Success ratio of wildcat wells in the United States.

1947 DRILLING ACTIVITY

IN spite of serious shortages of equipment, the oil industry in the United States set a new drilling record of more than 113 million feet in 1947. The number of wells drilled for petroleum increased 11.8 percent to 30,825. This was close to the all-time record of the industry in number of wells.

Wildcatting, stimulated by the oil scarcity and high crude prices, was active throughout the year. The total of 5,330 wildcats completed was 764 or 16.7 percent greater than in 1946. Exploitation wells excluding input gas or water wells totaled 12,546 in 1947 compared with 11,506 in 1946, an increase of nine percent.

Success ratio of exploration wells was better in 1947 than in 1946. Eighty percent of the wildcats were dry compared with 83.4 the previous year; 15.5 percent found oil compared with 13.9, and 4.5 found gas compared with 2.7. In the case of exploitation wells the success ratio was poorer last year, as producers stepped a good many wells out too far in the effort to increase production of known fields. Of the 12,546 exploitation wells drilled, 42 percent were dry compared with 39 percent of 11,506 exploitation wells in 1946. Combining development and wildcat wells, the record shows 31 percent dry in 1947 compared with 30 percent in 1946.

Geophysical and geological activity increased throughout the year as equipment and trained personnel became available. In December there were 491 geophysical crews in the field according to figures gathered by the Interstate Oil Compact Commission. This compares with 367 at the end of 1946, an increase of 25 percent. Crews in the field in December were divided as follows: 388 seismic, 96 gravity, and seven magnetometer. This compares with 251 seismic, 95 gravity and 21 magnetometer the previous year.

Most of the geophysical activity was centered in Texas, Louisiana and Oklahoma. Wyoming and Mississippi also revealed active work. In Texas there were 154 seismic and 32 gravity crews at work in December. Of this number, 50 seismic and 11 gravity crews were in West Texas where production has increased 300 percent in the past six years, and 1947 discoveries were more promising than on the Gulf Coast.

Louisiana was being explored by 83 seismic parties and 23 gravity crews, of which 65 seismic crews and 15 gravity crews were at work in the southern part of the state. In 1947 the state of Louisiana leased 1,200,000 acres of submerged tidelands to oil companies at an average bonus of $11 per acre and an average annual rental of $5.50 per acre per year. This leasing policy plus actual completion of the first producer in the Gulf of Mexico is expected to increase tideland exploration to a marked degree.

Discovery of oil in a deep test in the western part of the Anadarko basin in Oklahoma has opened a large untested area to drilling in that state. McClain and Garvin county discoveries also have tended to stimulate exploration, as is suggested by the operation of 42 seismic and two gravity crews in December compared with only 25 seismic and three gravity crews a year earlier. Discovery ratios in wildcatting in central Oklahoma were high in 1947.

Only 13 seismic crews were operating in California in December, a decrease of one from December, 1946, reflecting the discouraging results of recent years. No major field has been found in that state since 1938, and new discoveries in 1947 represented only six percent of consumption for the year. Reappraisal of previous discoveries kept the reserves from declining seriously.

New fields discovered in the United States generally in 1947 appear to have been small. Some discoveries cannot yet be properly evaluated. One such is Slick-Plymouth, Ellenburger lime, discovery in West Texas, which will require a lot of expensive drilling before its reserves may be confidently estimated. As a whole the industry in the United States again was unable to discover as much new oil as was produced to supply current demand.

American Petroleum Institute reserve estimates for Dec. 31, 1947, had not yet been compiled as this was written, but other unofficial estimates of known crude and condensate reserves range from 23 to 24 billion barrels compared with 21.9 billion barrels shown by the API a year ago. As has been the case for a good many years now, the discovery of oil in new fields was not sufficient to offset the production of 1.85 billion barrels. The indicated increase in underground inventory resulted largely from reappraisal of oil fields in the light of outpost drilling and improved producing techniques.

U. S. WELLS DRILLED FOR PETROLEUM

Year	Oil	Gas	Dry	Total
1947	17,876	3,415	9,534	30,825
1946	16,072	3,223	8,273	27,568
1945	14,283	2,794	7,463	24,540
1944	13,028	3,067	7,009	23,104
1943	9,717	1,782	6,385	17,884
1942	11,492	2,068	5,504	18,064
1941	19,552	3,007	7,128	29,687

WILDCATS

Year	Total	Oil	%	Gas	%	Dry	%
1947	5,330	825	15.5	245	4.5	4,260	80.0
1946	4,566	637	13.9	127	2.7	3,803	83.4
1945	4,190	545	13.0	136	3.0	3,509	84.0
1944	4,324	633	14.7	117	2.7	3,574	82.6
1943	3,642	499	13.7	72	2.0	3,171	84.3
1942	3,166	466	14.7	57	1.8	2,643	82.2
1941	3,264	650	20.0	83	2.5	2,531	77.5

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International News Notes

Shell Acquires Heysham Refinery

Agreement has been reached between the British Board of Trade and the Shell Group for the purchase by the latter of the government-owned refinery at Heysham, Lancashire. The plant was built during the war for the production of aviation fuel and was operated jointly by Shell, Trinidad Leaseholds and Imperial Chemical Industries. The oil refining unit, which comprises about half the total area of 300 acres and about two-thirds of the facilities, was closed in July, 1946.

When alterations have been completed, the refinery will produce gasoline by straight distillation together with gas oil and fuel oil. It will operate on crude from the Middle East, the first tanker load of which has been shipped. It is expected that the plant will be working at capacity by early summer with a throughput of 30,000 barrels daily.

Drilling Program in Argentina

As a partial means of fulfilling the exploratory program included in the Five Year Plan of the Argentine government and after negotiations which extended over a period of months, YPF has signed a contract with Drilling & Exploration Company of Dallas, Texas, for the drilling of forty exploratory wells in Argentina. It is estimated that the drilling operations will extend through approximately three years and that the wildcats will test the oil-bearing capacity of a series of formations considered by YPF geologists as favorable oil structures.

Drilling & Exploration Co. will move to Argentina complete drilling equipment which will be operated by expert North American personnel and will supply casing. The drillings will be exclusively of an exploratory nature and will take place in areas indicated by YPF. The decree of the government declares: "A plan of extraordinary features has been outlined with the purpose of intensifying crude oil production and with view to achieve self-dependence in that important phase of the national economy." It stresses the importance of oil exploration throughout vast areas of the nation, the geological survey of which has been estimated to cover 600,000 square kilometers.

R. H. SHERMAN has resigned as a vice president of Creole Petroleum Corp. to become assistant coordinator of producing activities for Standard Oil Co. (N.J.) He will continue as a director of Creole. A Freie, formerly production manager of the Creole Petroleum Corp. in Caracas, Venezuela, will assume the duties formerly assigned to Mr. Sherman as head of the producing section of Creole's New York office. Mr. Freie has been associated with Jersey Standard interests since 1929 and has spent the last 17 years in Venezuela in geological and producing activities.

Oil Men Visit Colombia

Recent visits of North American oil men to Colombia are taken as indications that some companies not heretofore identified with oil activities in that country are looking it over with a view to possible acquisition of concessions or of exploratory rights. One party that arrived in Bogota shortly after the first of the year consisted of representatives of Stanolind Oil & Gas Company including Frank D. Manning, landman; Gordon Buskirk, geologist; Thomas W. Caffey, lawyer, and H. Porter, industrial relations. Stanolind is reported to be interested in inspecting private oil lands along the Pacific Coast south of Buenaventura.

Another party of visitors is made up of Ohio Oil Company officials: Fred S. Funk, production department; W. D. Henderson, geologist, and B. D'Artois, lawyer. Accompanying them is D. R. Knowlton, former head of the foreign department of Phillips Petroleum Company who is acting as consultant for Ohio.

British Made Drilling Bits

In line with the expansion of British activity in the production of oil field equipment, certain firms have directed attention to the manufacture of rock bits which heretofore have been supplied almost exclusively by American companies. In a test well drilled by Bremmer Well Drilling Company for D'Arcy Exploration Company at Willesden, near London, a new type of bit was used with highly satisfactory results in penetrating difficult formations.

These bits, made by Carbonmetals, Ltd., a London company, are of solid construction with cutting edges faced with a metal of extreme toughness known as "Carbonmetal." The absence of moving parts lends additional strength to the bits, and they have proved highly successful in obtaining satisfactory cores not only in the harder rocks but also in the more friable formations. The bits have been used in drill tests for coal as well as for oil, and cores ranging up to 100 percent recovery have been obtained.

PRODUCTION of crude oil in Venezuela during the month of November amounted to 37,230,381 barrels. Exports for the month were 32,165,481 barrels. Production by companies was as follows:

Company	West	East	Total
Creole	13,504,084	4,610,354	18,114,438
Mene Grande	1,813,536	4,604,509	6,418,045
Shell	10,732,165	—	10,732,165
Consolidada	—	594,845	594,845
Texas	190,088	184,995	375,083
Socony	—	900,752	900,752
S.A.P.			
Las Mercedes	—	1,235	1,235
B.C.O.	35,520	—	35,520
Orinoco	6,805	—	6,805
Phillips	—	50,431	50,431
Varco	—	1,062	1,062
Guasare	—	—	—
TOTAL	26,282,198	10,948,183	37,230,381

Shell-Mex and B. P. Appointments

O. T. Brunner, C. H. S Haygarth and A. Hyman have been appointed assistant general managers of Shell-Mex and B.P. Ltd. Mr. Brunner joined Shell-Mex, Ltd., in 1926 and was manager of the statistical department of Shell-Mex and B.P., Ltd., when the war came on. He then was named secretary to the management committee of The Petroleum Board. Last January he was made acting secretary of the Petroleum Board.

Mr. Haygarth joined The British Petroleum Co. in 1920 and was general sales manager at the time of the merger, from which time he occupied that position for Shell-Mex and B.P., Ltd. He has been joint general sales manager of The Petroleum Board since 1939.

Mr. Hyman joined Shell-Mex, Ltd., in 1924 as assistant to A. W. Lawson in the development department. He was made department manager in 1937. At the outbreak of the war he became manager of the inland distribution department of The Petroleum Board.

Death of Richard Airey

Richard Airey, for many years a prominent figure in the international oil industry, died February 1 at his home in Billingshurst, Sussex, England, at the age of 79. He was closely associated with Sir Henry Deterding, and in 1916 went from England to the United States as American representative of the Royal Dutch Shell Group, a post which he held for some twenty years. He set up offices for the Asiastic Petroleum Company and subsequently became president of Caribbean Petroleum Company and Colon Development Company, Venezuelan subsidiaries of the Shell Group. He also served as a director of Shell Union Oil Company and Canadian Eagle Oil Company.

During World War I Mr. Airey acted as adviser to the British Admiralty on the procurement of American oil for the British Navy. In 1935 he returned to England and shortly afterward retired from active business but continued to take a close interest in petroleum affairs and was frequently called upon to act in an advisory capacity.

Survivors of Mr. Airey are his widow, Mrs. Louisa Mary Airey, and two daughters, Mrs. Gordon H. Michler, of Greenwich, Conn., and Mrs. Clyfford Trevor, of New York. His two sons were killed in action while serving as officers of the Royal Navy, George Airey in World War I and Richard R. Airey in World War II.

Forms Foreign Department

Stanolind Oil and Gas Company has established a foreign exploration department for the purpose of conducting exploratory work in Canada and Colombia. C. T. Jones has been appointed manager of the new department. Division offices will be opened at Calgary, Alberta, and at Bogota. Before his new appointment, Mr. Jones was manager of the geophysical department for Stanolind.

Iran's Production

Production of crude oil in Iran during the twelve months ending Dec. 31, 1947, is reported as roundly 154,000,000 barrels or approximately 422,000 barrels daily. This compares with an average of 401,000 barrels daily in 1946.

New Venezuelan Contracts

Royalty contracts yielding more revenue to the Venezuelan government were signed by Creole Petroleum Corporation and all other producers on Jan. 22 in Caracas at the Ministry of Development. In an official announcement from the Minister, Dr. Juan Pablo Perez Alfonzo, it was stated that the Venezuelan government had proved through its recent auction of royalty oil that higher prices are obtainable at this time. The government royalty in 1948 is estimated at 12,500,000 cubic meters (78,622,000 barrels) which will not yield $13,500,000 in additional revenue, making the total government oil royalty in 1948 approximately $186,750,000. This arrangement will be more profitable to Venezuela than agreements with outside interests. The government will retain, however, its option of trading some of the royalty petroleum for merchandise if it is compelled to do so due to a scarcity of merchandise in Venezuela. Argentina will receive Venezuelan royalty petroleum in exchange for meat under a two-year contract.

A breakdown of the terms of the new agreements with the producing companies reveals that they will pay an average of $1.08 above the normal price per cubic meter except on the amount already sold in October. The new price for royalty oil began with November, 1947, production.

Bachaquero Zulia is the lowest quality cited $1.86252 per barrel). The highest is El Roble Guarico ($2.70894 per barrel). There are in all a total of twenty prices quoted. All prices may go up according to the market, but they may not sink below those guaranteed in the agreement.

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OIL COMPANY STAFF CHANGES

Gage Lund

GAGE LUND has been elected a director of the Standard Oil Company of California. He has been chairman of the board of The California Co. and the Standard Oil Co. of Texas, both wholly-owned subsidiaries of Standard of California. They operate in the Rocky Mountains, Texas and the Southeast. Mr. Lund joined Standard in 1925 and worked as a geologist and drilling foreman in the Rockies and Texas for the next eleven years till he became division superintendent of The California Company's Gulf Coast division, with offices in Houston.

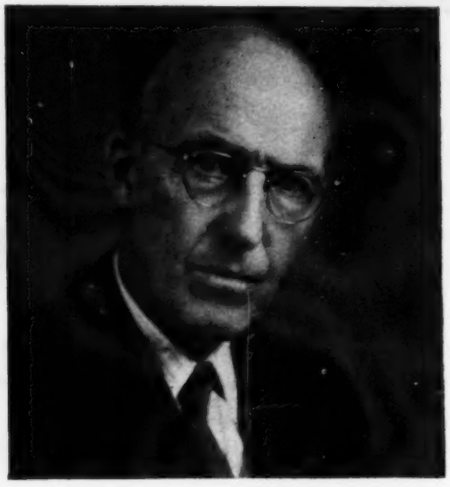
In 1938 he was made assistant manager of all operations of The California Co. and Standard of Texas, and three years later was elected president of The California Co. Election as chairman of both companies came in 1945, with headquarters in San Francisco. These two companies have active interests in 17 states. Their gross production of crude oil exceeds 100,000 barrels daily.

RALPH CHAMPLIN, director of public relations of Ethyl Corp., has been elected chairman of the committee supervising the oil industry's public relations program. The name of the committee was changed to the Oil Industry Information Committee. During 1947 it was known as the Public Relations Operating Committee. The name was changed in order to reflect properly the program's industry-wide character, it was explained.

Mr. Champlin succeeds Franklyn Waltman, director of public relations for the Sun Oil Company, who headed the committee during the major part of its initial year of operation.

Four vice chairmen were named, each in charge of a special phase of the program. They are: H. L. Curtis, Shell Oil Co., in charge of advertising; W. R. Huber, Gulf Oil Corp., in charge of the committee's supply-demand conservation program; George Freyermuth, Standard Oil Co. (N. J.), in charge of general publicity; Conger Reynolds, Standard Oil Co. (Ind.), in charge of industry relations.

C. S. MITCHELL of Chicago has been appointed manager of the new crude oil purchasing and sales department of Cities Service Oil Co. (Del.) Mr. Mitchell has been with the company since 1930. Among other assignments he was assistant superintendent of Cities Service Gas Company's production operations in the Texas Panhandle and later was promoted to the industrial sales department of that company.



H. R. Straight

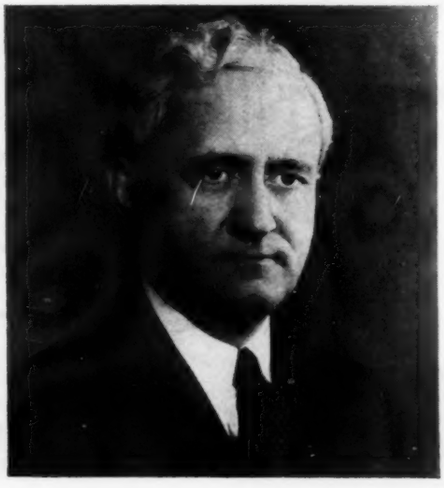
H. R. STRAIGHT has retired as chairman of the Cities Service Oil Co. after more than 36 years with the company. He remains as a director of Cities Service Oil Co. (Del.) and will occupy office space in the Masonic Building, but has withdrawn from active participation in company operations. Mr. Straight came to Oklahoma in 1911 with the T. N. Barnsdall interests and one year later joined the Henry L. Doherty organization as manager of a group of oil and gas properties with headquarters in Bartlesville. He was elected president of his company in 1937 and chairman in 1946.

J. A. de LANOY, vice president and manager of the materials department of the Asiatic Petroleum Corp., retired December 31, 1947, after a period of more than 25 years with that company. S. J. Veenstra has succeeded Mr. de Lanoy.

CONGER REYNOLDS, director of public relations for Standard Oil Co. (Ind.), recently was given an award for "doing most to improve the techniques and applications of public relations through top-flight efficiency." The award was made at the eleventh annual awards dinner of the National Association of Public Relations Counsel, Inc., at New York.

In responding to the award, Mr. Reynolds said that the successful public relations man must act as a sort of conscience for his organization keeping before it the question of whether its acts are in the public interest.

Conger Reynolds



H. E. DISCHINGER, for the past year superintendent of Shell Oil Company's East products pipeline which runs from Wood River, Ill., to Lima and Columbus, Ohio, has been named general superintendent of the company's products pipeline department in charge of operations. He will make his headquarters in New York and will supervise operations of all pipelines and terminals under the department's jurisdiction.

PAUL C. SHEA, former vice president and director of the Carter Oil Co., has been appointed as assistant to the general manager of the supply and transportation department of the Esso Standard Oil Co. The assignment was effective Feb. 1.

Mr. Shea, an Esso man since 1926 when he became a helper at the Everett refinery, was a technical assistant to the vice president of the Colonial Beacon Oil Company and later was named a vice president and refinery general manager at Everett. He went to the Carter organization on a loan basis in 1945 when he was made acting manager of manufacturing of its northwest division.

G. STEWART BROWN, former State Department official, has been appointed as manager of the public relations department of the Standard Oil Co. of Calif. Mr. Brown, for many years a foreign correspondent in Europe, has had a wide variety of experience, including service with the American Red Cross as national vice chairman in charge of public relations and as director of public relations of the Allied Commission in Italy.

THEODORE R. CORBETT has been appointed manager of the manufacturing department of The Carter Oil Company. For the past year and a half he has served as manager of Carter's northwest division manufacturing department. Headquarters for all of the Carter manufacturing operations, formerly in Tulsa, will be centered in Billings. Mr. Corbett started his career in the field of petroleum refining in Billings 17 years ago as a chemist for the Yale Oil Corporation's refinery, which was acquired by Carter in 1944.

WILLIAM PETER GAYNOR, JR., has been elected vice president and general manager of Overseas Tankship Corporation, which currently operates and owns or charters a fleet of approximately fifty ocean-going tankers in overseas service. Mr. Gaynor, who is an associate member of the Society of Naval Architects and Marine Engineers, last November completed 35 years of service with this and other Caltex affiliates. All of this time, except for a period of one year, he has been in marine activities.

Wm P. Gaynor, Jr.

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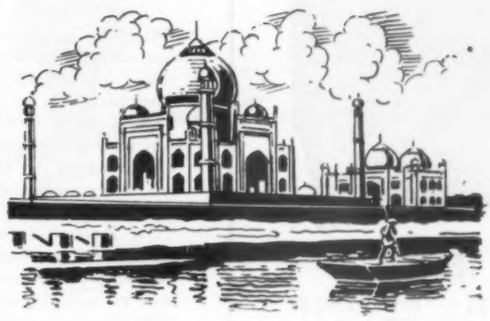

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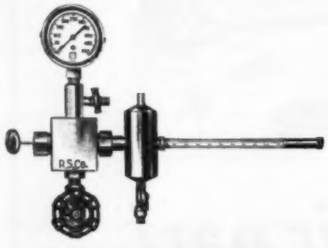

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WRITE FOR CATALOG NO. 30-A

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R. G. Follis

T. S. Petersen

BECAUSE of the widening scope of company activities the directors of Standard Oil Company of California decided early this year to broaden its executive administration. In pursuance of this policy as announced by H. D. Collier, chairman of the board, a new post, that of vice chairman, was created and has been filled by the appointment of R. G. Follis who has been president of the company since 1945.

T. S. Petersen, former vice president and director, was elected president to succeed Mr. Follis. Mr. Petersen joined the company in 1922 and was connected with its marketing division in various capacities until 1938 when he became manager of employee relations and director of personnel. His next post was that of general manager of sales. In 1942 he became a member of the board, and for the past several years he was engaged in general administrative duties as an assistant to Mr. Collier and Mr. Follis.

W. ALTON JONES, president of Cities Service Co., has been awarded the President's Certificate of Merit. Presentation was made by Secretary of the Army Royall on Feb. 6. Secretary Royall praised Mr. Jones' efforts in developing the big and little inch lines and his services to the nation as president of War Emergency Pipelines, Inc.

CARL E. BOLTE has been elected vice president in charge of sales of the Battenfeld Grease & Oil Corp., Kansas City. He has been executive secretary of the National Lubricating Grease Institute since July 1, 1946. The NLGI headquarters staff will carry on the Institute's work until his successor is named.

NORMAN THOMPSON has been appointed assistant superintendent in charge of laboratories at Sun Oil Company's Marcus Hook refinery. George S. Rostron was made special assistant to Mr. Thompson, and Charles C. Kline operating engineer of a new wax manufacturing plant and new furfural solvent extraction plant.

CHARLES L. HARDING has been elected a director of Socony-Vacuum Oil Company, Inc. Mr. Harding, formerly a member of the law department, has been coordinating Middle East interests of the company for the last seven months and will continue to function in this capacity.

August C. Klein

Dr. August C. Klein, vice president and engineering manager of Stone & Webster Engineering Corp., died suddenly on Feb. 3, due to a coronary thrombosis while on vacation in Montego Bay, Jamaica, B.W.I. After his services in World War I, Dr. Klein became a gas engineer with Stone & Webster Engineering Corp. in its Boston office. In 1929 he became chief mechanical engineer of Stone & Webster and during World War II he was detached from other work of this organization to take charge of several TNT plants being built for the United States Army.

In 1942 he became project engineer on the Stone & Webster work for the Manhattan Project. During this period he supervised the engineering design of the first atomic pile at the Argonne Forest Laboratory of the University of Chicago and the great electromagnetic uranium separation plant at Oak Ridge, Tennessee. Incidental to this work, he was in charge of the layout and design of the city which bears that name. In 1945 he became engineering manager of Stone & Webster Engineering Corp and a year later was elected vice president.

Heads San Francisco Export Managers

Vic Indig, San Francisco export factory representative of the Patterson-Ballagh division by Byron Jackson, Overstrom & Sons and Commercial Iron Works, was recently elected president of the Association of San Francisco Export Managers.

ANDREW NEILSON has been elected president of Overseas Tankship Corp., an affiliate of Caltex. Mr. Neilson has been directly connected with shipping activities for the past 25 years. Most of this time has been spent with affiliates of Overseas Tankship, either afloat or ashore, particularly as general manager of Pacific Tankers, Inc., San Francisco, until he joined Overseas Tankship Corp. as vice president and general manager in June, 1946. Overseas Tankship is currently operating a fleet of approximately 50 tankers in overseas service.

Andrew Neilson

....OF COURSE THEY ARE
DISCUSSING THE FEATURES OF
DIKKERS OIL VALVES

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Valve makers since 1879

Hudgins Appointed Sales Agent

The C. Lee Cook Manufacturing Co., Louisville, Ky., has announced the association of T. F. Huggins with its mid-continent agent, the Woobank Machinery Co., Tulsa. His headquarters will be in Houston. Mr. Hudgins has long been active in the oil and natural gas industry. He was formerly vice president and sales manager for the Cooper-Bessemer Corp. and later export sales manager for Clark Bros. Co.

Robert I. Watson Dies

Robert I. Watson, who was associated with oil company activities in India and Burma for over forty years and who retired from the chairmanship of Burmah Oil Company, Ltd., only on December 31, passed away at his home in Pangbourne, Berks, England, on January 26. Mr. Watson had been connected with the Burmah Oil Company practically from the time of its organization, first in the offices of its Indian representatives and later in London where he served for 27 years as its managing director. On the retirement of Sir John Cargill in 1943, he became chairman of the board, a post which he held up to the time of his retirement.

Represents Hechtel In New York

George Gibson, former director of construction of PAW, has been appointed New York representative of Bechtel Corp. Before the war Mr. Gibson was affiliated with C. H. Leach Co., manufacturers of specialized refinery equipment, becoming sales manager and chief process engineer. In recent years he has been identifid with Hoover, Curtis & Ruby and with other organizations in a consultative capacity.

Oil Well Supply Promotions

Appointment of August R. Maier as director of engineering and of Alexander Quayle as chief engineer of Oil Well Supply Co. has been announced. Mr. Maier's new headquarters is in Dallas, Texas. Mr. Quayle will remain in Oil City, Pa., where he has been serving as assistant chief engineer. Mr. Maier joined Oil Well in 1930 as a development engineer at the company's Wilson Snyder Manufacturing Division in Braddock, Pa. He was transferred to Dallas as assistant chief engineer in 1932 and was new chief engineer four years later. His headquarters was moved to Oil City in 1941.

W. H. Davison

Largest Portable Field Laboratory

Completion of a portable field laboratory for core analysis, believed to be the largest of its type in the world, is announced by W. H. Davison, president of Core Laboratories, Inc. The new laboratory is an addition to the fleet of portable units maintained by the company which now numbers 22 in addition to large stationary laboratories at Dallas, Houston, Corpus Christi, Shreveport, Oklahoma City, Evansville and Bakersfield. It will operate from a semi-permanent location in the Rangely field, Colorado.

The laboratory, engineered and built under the direction of John D. Wisenbaker, manager of operations, at a cost of approximately $10,000, is of all-aluminum construction, slightly over 28 feet in length and weighs 6,000 pounds. It is designed specifically to analyze simultaneously 60-foot cores indigenous to drilling in the Rocky Mountain area. With nine engineers, under the supervision of John D. Harris, district engineer, it will provide continuous 24-hour service and will greatly facilitate drilling operations in its territory.

Company Changes Name

The name of the Standard Oil Company of New Jersey has been changed to the Esso Standard Oil Co. The change gives formal recognition to the close association which has developed in the public's mind over a period of years between the corporate name of the company and its Esso trademark, and will minimize confusion with the name of the parent company, Standard Oil Co. (N. J.)

Elected Vice President of Ideco

James F. Simpson, for the past four years assistant secretary of Dresser Industries, Inc., Cleveland, has been made vice president of The International Derrick & Equipment Co., a Dresser subsidiary. A native Texan and former resident of Dallas, Mr. Simpson will return to his home city with offices in the Ideco Building.

Succeeds the Late J. B. Pillin

Alonzo Limb has been elected chirman of J. B. Pillin & Co., Ltd., equipment manufacturers of Beckenham, Kent, in succession to J. B. Pillin who died recently. Mr. Limb is joint managing director of C. C. Wakefield & Co., Ltd., and was appointed deputy chairman of Pillins after the company joined the Wakefield group in 1947.

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These are the Advantages of LANE-WELLS BOCL PACKERS for Deep Well Operations

When excessive tubing stretch complicates deep well operations and starts to add gray hairs to the operators head, it's time to cut down that worry with a Lane-Wells BOCL Packer — the long-stroke valve, hook-wall packer which packs-off the first time without danger of being jerked loose. Let's look at the advantages in detail. Long-Stroke Valve. 30-inch stroke does away with the danger of unsetting the packer when picking up the tubing.

Flopak Valve. Gives positive seal, even at 7,000 lbs. p. s. i. differential pressures and 300° F., *and with obstructions on the seat!*

6-Ring Floseal Packing Ring. Packs off positively under as much as 7,000 lbs. p. s. i. differential pressure, at temperatures up to 300° F. and more, and can be set and reset many times.

Dove-Tailed Slips with Cross-Cut Wickers. Won't hang up on collars, but release when they're supposed to without shaving casing or clogging.

Free-Wheeling Cage Assembly. Takes twisting strains away from slips and rings, insures positive action of locking and releasing mechanism.

In addition, this Lane-Wells BOCL Packer runs faster through fluid, and the circulating valve permits equalization of pressures before pulling. Ask your Lane-Wells representative how the BOCL saves headaches on deep well jobs, or see your Composite Catalog for full details and dimensions.

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Factors Governing Rotary Drilling Rates

(Continued from page 79)

and method of manufacture have been improved. Methods of fixing cutting edges with hard alloys have been further developed, and teeth forms have shown greater variation allowing the selection of more suitable types for a given formation. These developments came about primarily prior to 1940 but have come into general use since. Also a much wider range of formation types are now drilled with rock bits, in fact all but sticky clays or shales.

The amount of increase in rate of penetration that may be credited to bit improvements since 1939 or 1940 cannot be stated in figures, but certainly it has been considerable. Here again pump volume has been an essential factor.

Improvements in drill pipe, drill collars and other hole equipment have had to do with overall improvement in drilling efficiency rather than in rate of penetration itself, with the exception of the use of more weight because of heavier drill collars and improvements in the other parts of the drilling shaft itself. The use of heavy drill collars, but with little weight on the bit and fast rotation, has improved the drilling rate in steep beds.

We now come to the most difficult of all factors to evaluate, that of the improvement in the ability and knowledge of the men who actually do the work. In the twenties and early thirties drilling crews and engineers were limited by the capacity of the equipment at their disposal. Now there is no such limitation for the flexibility of drilling equipment and drilling tools reaches considerably beyond the extremes of their use, except, possibly, fluid volume in some formations. Studies ranging from 1932 to 1939 indicated more than a fifty percent increase in rate of penetration that could be credited to personnel and equipment. These two could not be separated, though without question the personnel factor accounted for at least one half of that increase. Engineers became more conversant with the problems of drilling and were given more authority. Drillers and other members of the crew abandoned their rule of thumb practices and undertook and carried on their work in a manner that had sound engineering principles as its basis. Machinery improved, giving them less laborious and more interesting methods of work. Meetings were organized to instruct the crews in the basic principles of mud control and other drilling practices, and in the end many crew members attended schools in which such subjects were taught. There were vast improvements in the capacity and attitudes of the drilling crew between 1932 and 1939.

This improvement continued probably until 1942 which year-marked the beginning of our first all-out effort in the recent war.

An analysis of the operation of one drilling company in several areas indicates an actual decline in drilling efficiency, both overall and in rate of penetration during the years 1942, 1943 and 1944. There had been no changes in material and equipment with the exception that many operators felt that bits in use during the war period were inferior in manufacture and material to the same tools used prior to 1942 and since 1945. The bit manufacturers insist that there were no changes in either material or methods of manufacture. Fluid volumes, weight on the bit, rotating speeds and everything else was the same, but during 1942 and through 1944 there was an actual decrease in efficiency of some ten to fifteen percent, as nearly as can be estimated from a careful study of the results obtained by one operator running fifteen to twenty strings of tools in several fields in California and Texas. These results were checked with other operators.

During this 1942 to 1944 period and into early 1945, drilling crews suffered the loss to the armed services of many of their experienced members, engineers, drillers and roughnecks. These men had to be replaced with those of less ex-

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perience. The spirit of competition was weakened, and as evidenced by the work accomplished, the factor of personnel accounted for a substantial decrease in drilling efficiency which affected every phase of the operation from the commencement of rigging up through the drilling and to the completion of the well.

Since 1944, the bottom of the trough, the increase in the rate of penetration in wells drilled by this drilling organization is twenty to thirty percent. Other drilling organizations have had similar experiences, though one company indicates an increase of forty percent in overall efficiency including rate of penetration during the same period. The year 1932 is used as the base year. The industry has now reached and gone somewhat beyond the maximum efficiency acquired in the period 1939-1942. Personnel has been improved, the spirit of competition and the pride in doing a good job have been somewhat restored, and the mechanical factors and practices have been brought back to their 1941 optimum and carried on beyond.

In summation of the foregoing discussion, it would appear that since 1939 there has been improvement in overall drilling efficiency, including rate of penetration, though it is less marked than the improvement shown from 1932 to 1939 and especially 1935 to 1937. An actual decrease occurred in 1942, 1943 and 1944. (See graph)

Practices and equipment which affect rate of penetration have brought little change during the past eight years, for the practices of 1947 were in use, or at least fairly well known, in 1939 and the machinery, except parts of power rigs, had been developed. They are in fairly general use now, however, having become so through a gradual dissemination of knowledge of correct drilling practices and equipment usage that were developed and perfected by relatively few operators.

There is still room for great improvement in drilling practices and the resulting increase in rate of penetration and overall well drilling efficiency. It appears that the most important of these is personnel, and the general use of those practices which have proved to be the best. Mud-laden fluids, both in character and volume, may be improved. The cutting tools on bottom are likewise subject to considerable improvement and principally toward that tool that will penetrate a much greater thickness of formation before it must be withdrawn from the hole and changed for a fresh or sharp bit. In addition to these, overall improvements in the drilling shaft and above-ground equipment, even to radical changes in the type of rig, may and will cause greater improvement in the overall operating efficiency of a drilling rig and in time consumed between spudding and completion.

A more general use of the presently-known best drilling practices and machines in their properly balanced relationships would result in greater efficiency and the decrease of overall well cost to the industry.

To Expand Research Program

Cities Service Research and Development Corp. has been organized to direct the far-flung research activities which have been carried on by individual operating companies of Cities Service for more than 30 years. The program will cover the entire petroleum field, extending into the realm of plastics, detergents, medicines, paints and lacquers, as well as synthetic fuels. The project will strengthen petroleum resources.

Among major development projects which the new corporation will direct is intensive research in cooperation with The M. W. Kellogg Company, in the synthesis of liquid petroleum products from natural gas at both the Jersey City, N. J., plant of Kellogg, and the Cities Service refinery at Lake Charles, La. Others include intensifying and centralizing work on the development of automotive and household fuels at the Cities Service refineries at Lake Charles and East Chicago, Ind.; the development of chemicals from natural gas at Tallant, Okla.; and the development of lubricants and greases at Ponca City, Okla.

W. Alton Jones, president of Cities Service Co., will serve as chairman of the board of the new corporation. A. P. Frame will be president and C. L. Mateer, vice president. Mr. Frame will continue in his present position as vice president of Petroleum Advisers, Inc., in charge of all manufacturing operations of Cities Service oil companies.

Sets Safety Record

In a record-breaking run of 3,476,721 injury-free manhours, the Shell Oil Company's Wood River, Illinois, refinery has processed more than 16,000,000 barrels of oil, H. D. Dale, refinery manager, announced. The 164 days that Wood River's 3,800 employees recently worked without a lost-time injury is a record for all Shell installations. The production figure it helped make possible is a new high for the refinery and is substantially above the plant's rated capacity. The safety record is remarkable because it was achieved at a time when large-scale maintenance and construction work, usually accompanied by an increased injury rate, was under way at the refinery.

Thornburg Blasts Senator Brewster

From far away Bahrein in the Persian Gulf, Max W. Thornburg, foreign industrial consultant who was petroleum advisor to the State Department of the United States during the late war, has addressed a hotly-worded letter to Senator Owen Brewster for the latter's offhand charge during a committee hearing in Washington that Mr. Thornburg had been "planted" in the Department by oil companies with which he formerly had been connected. Referring to this allegation, Mr. Thornburg wrote:

"Your unfounded and irresponsible statement that I was placed in the Department of State by the oil companies, or by any one of them, could have been disclosed as false merely by inquiring of that Department how I came to be selected and appointed. You would have learned that I, personally, was asked by the Department of State to serve as Petroleum Advisor before any oil company with which I was connected knew anything about it; that the reason I was asked was because I had many years of experience with major oil companies in both domestic and foreign work; and that before I was asked, the Department had invited another and far more widely known major oil company executive, who refused the appointment. He told me later that he had declined largely to avoid becoming a target for attack by just such irresponsible politicians as yourself. My own (parent) companies, Standard Oil of California and the Texas Company, agreed with reluctance to releasing me for that duty, because of similar misgivings on their part when I informed them of the Department of State's request."

Mr. Thornburg goes on to review the record of his association with the State Department and replies in detail to the Senator's allegation that he tried to promote a lend-lease deal with Saudi Arabia so that his company would obtain oil rights there (disregarding the fact that the oil concession had been granted several years earlier). As a review of the work of the State Department's petroleum division during the war, the letter is illuminating, but to those familiar with the record, no defense is necessary.

Preparation of pipeline right of way in the East Indian tropics is made difficult by the tremendous annual rainfall of the region.

To Market Gas Well Flowmeter

Stanolind Oil and Gas Co. has granted The Lane-Wells Co. the use of the bottom-hole gas well flowmeter developed in Stanolind research laboratories. The instrument, contained in a tube two and a quarter inches in diameter by seven feet long, is lowered down the tubing of gas wells with an ordinary piano-wire depth measuring line and records production from each gas sand while the well is flowing. The instrument may also be used on gas injection wells. This gas well flowmeter has been used in the Hugoton gas field to plan well workovers, in indicating the necessity of acidizing and in checking on the results of acidizing and workovers. It has, in effect, added a large amount of gas reserves to the field, since portions of gas sands previously considered non-productive in particular parts of the field have been shown to contain large quantities of gas and have consequently been produced by additional well completions. Conversely, in certain parts of the field, other sands previously considered productive have been shown to be producing only a small percentage of the total gas from the well; many unprofitable workover jobs have thus been avoided.

The instrument consists essentially of a detecting element, a recording chart and a small motor, powered by flashlight batteries, which operates the recording mechanism. The detecting element is a hot wire anemometer connected in a Wheatstone bridge circuit to measure the resistance change of the hot wire as it is cooled by flowing liquids. This change is recorded on a chart as a function of time.

Cooper-Bessemer To Expend $600,000

The Cooper-Bessemer Corp., manufacturers of diesels, gas engines and compressors, has embarked on a $600,000-improvement program in an effort to increase its production of equipment sorely needed to help alleviate the shortage of natural gas. The program calls for the purchase of $325,000 worth of new machine tools for its Grove City, Pa., plant and the expansion of its foundry facilities, and about $275,000 for equipment for the Mount Vernon plant. The machinery, which is largely to replace present equipment, consists of large facing tools and boring and drilling equipment. Company officials estimate that production will be increased by from 25 to 30 percent as a result of these expenditures.

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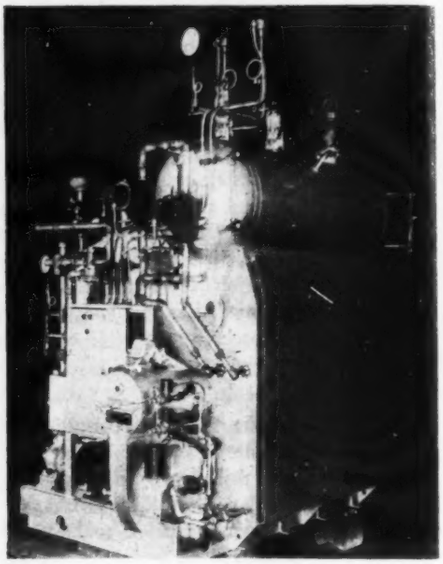

Unit Steam Generator.

Packaged Steam Generators

Foster Wheeler Corp. has developed a series of package steam generators up to and including 27,000-pound-per-hour range. These Foster Wheeler units are assembled at the factory, including refractory and insulation, and are ready to generate steam when delivered and installed. A bulletin containing full information is available on request.

LPG Carriers

Commenting upon references to the "Natalie O. Warren," recently put into service by the Warren Petroleum Company as the first ocean-going tanker designed to carry liquid petroleum gases, a British correspondent calls attention to the fact that at least two vessels were built in the United Kingdom for such service at earlier dates.

One of these, it is stated, was the "Agnita" of 4,559 tons deadweight, built for the Shell Group in 1931 specifically for the carriage of butane and propane and maintained in that service until sunk by enemy action in March, 1941. The other was the "Megara" of 10,751 tons, built in 1929, converted in 1934 to butane and propane transport and still employed for that purpose.

In drawing attention to this matter, the correspondent agrees that the "Natalie O. Warren" deserves a place of priority as probably the most completely equipped vessel built "solely" for the carriage of LPG products but suggests that for strict historical accuracy, she should be designated as the first U. S. flag tanker to enter such ocean-going service.

Stainless Steel Piping

A new booklet, Stainless Steel Piping — "Why and Where to Use It," has been written by J. D. Matimore, chief engineer of the product and research division of Tube Turns, Inc., Louisville, Ky. Tube Turns also has issued a new 20-page supplement to its catalog and Engineering Data Book No. 111, and a new booklet titled "Allowable Working Pressures." Copies of the various booklets are free on request.

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THE JOHNSTON *all purpose* GUN PERFORATOR

Gives you maximum PORTABILITY!

THE JOHNSTON GUN PERFORATOR is flexible in operation and so completely portable that the entire unit can be transported in your regular field car! For each perforating job you need only the Firing Head and the Perforating Gun Sections—no special depth measuring devices, firing equipment or extra assembling tools are necessary.

After delivering the Johnston Gun Perforator to the well, you can select the exact number of Perforating Gun Sections needed for the job. When the quantity of perforations is known, you simply attach the correct number of Perforating Gun Sections to the Firing Head and lower the entire unit on the bottom joint of tubing or drill string to the zone selected for perforation. Bottom-hole hydrostatic pressure fires the Johnston Gun Perforator automatically following definite rotary and vertical manipulation of the connecting string by the driller.

And if you want a formation and pressure test made on the same run of tubing or drill string, you simply connect the Johnston Gun Perforator to *your* regular Johnston Formation Tester and Pressure Recorder for *combined* perforate-and-test operations. It's the slickest possible way of obtaining water shut-off information, doing exploratory work or testing for actual production.

FLEXIBILITY and PORTABILITY

are only two of the *many* outstanding advantages of the Johnston "SHOOT-N-TEST" All Purpose Gun Perforator. Here are other important Johnston features to consider when contemplating Gun Perforator equipment . . .

SAFE gun perforator operation! The Johnston Gun Perforator will not fire until subjected to *both* in-the-hole hydrostatic pressure and positive rotary and vertical manipulation of the pipe string by the driller.

POSITIVE FIRE of all projectiles! The safe, fool-proof hydrostatic firing principle of the Johnston Gun Perforator coupled with the flush-hole design of the Perforating Gun Sections assures positive fire of all projectiles.

ANY NUMBER OF PERFORATIONS possible! Any number of four, five or six-shot Perforating Gun Sections can be attached to the Johnston Gun Perforator Firing Head to provide the exact quantity of perforations needed for each job.

EXACT POSITIONING in producing zone! Accurate placement of the Johnston Gun Perforator at the exact depth for perforating is easily determined by pipe-in-the-hole tally. No rigging-up of special measuring devices is necessary.

MINIMUM OF EXPENDABLE SUPPLIES! The Johnston Gun Perforator needs only a minimum of loading supplies for each perforating job. The Perforating Gun Sections require only seals, powder charges and projectiles for reloading.

FAST, EASY MAINTENANCE! The Johnston Gun Perforator is outstanding for its simplicity of operation and trouble-free construction. The simple procedure of disassembly, cleaning, loading and reassembly can be done right on the rig floor.

Write **for NEW DESCRIPTIVE FOLDER On The Johnston "SHOOT-N-TEST" Gun Perforator!**

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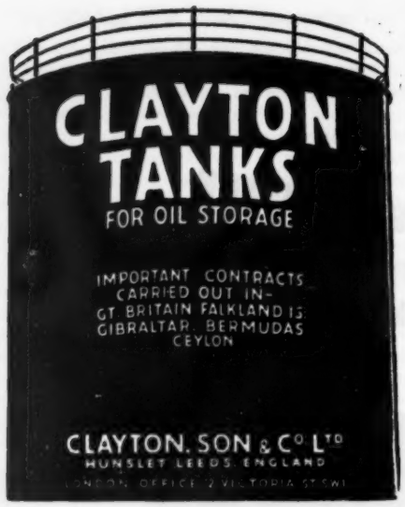

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Julius F. Roten

Julius F. Roten, 59, vice president and director of L. Sonneborn Sons, Inc., died January 24. Mr. Roten joined Sonneborn in 1905. An authority on petroleum derivatives, he was instrumental in the development of improved methods of refining white mineral oils, petrolatums and petroleum sulfonates and in creating new uses for these products in the manufacture of a great variety of end-products including cosmetics, pharmaceuticals, paper, rubber and plastics, and in many types of chemical processing.

J. DEAN BRADLEY, general superintendent of the Sarnia, Ontario, refinery of Imperial Oil, Ltd., since 1944, has been appointed manager of the operating division of the manufacturing division at Toronto. Mr. Bradley has been succeeded by Dr. J. L. Hudgett who has served Imperial in various capacities since 1914. N. W. McCrae has taken over Dr. Hudgett's former job as superintendent at Sarnia.

S. F. HEARD has been elected president of Royalite Oil Co., Ltd., of Canada, to succeed the late Alexander Hannah. Mr. Heard joined International Petroleum Co., Ltd., in 1920. Two years later he was placed in charge of wildcatting operations for Standard Oil Co. of Argentina. He joined Imperial in 1925 and in 1934 was transferred to western Canadian producing operations.

EARLE WALL formerly division exploration superintendent for the California Co., southern division, New Orleans, has been transferred to San Francisco in a staff capacity in the office of Gage Lund, chairman of the board of the California Company and of Standard of Texas. Mr. Wall will follow exploration and production activities of those two companies. He has been with the company since 1919 and has served as a geologist and in other exploration capacities in both domestic and foreign operations.

DOWELL INC. formed a foreign sales and export department to be located at the company's general offices in Tulsa. Management of the new department will be the responsibility of P. E. Fitzgerald who has been associated with Dowell for 15 years in various capacities including brief assignments in Canada, Mexico and Venezuela and for more than 10 years the company's geologist. He will continue in this capacity and will also retain his membership on the board of United Oilwell Service S.A., Venezuelan associate.

New Discovery In Egypt

Socony-Vacuum Oil Co., Inc., and Angle-Egyptian Oilfields, Ltd., have completed a well at Asl in Sinai about ten miles south of Sudr producing wells, at a depth of 3,872 feet. On a short production test the well flowed at a rate of 600 barrels daily of 22 gravity oil.

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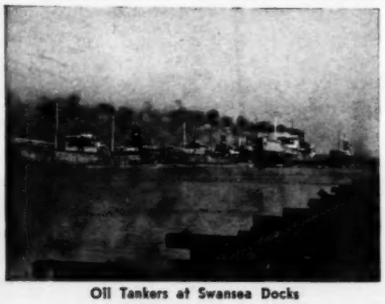

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REPRESENTATIVES IN PRINCIPAL CITIES OF THE WORLD

New UOP Pilot Plant

Complete fractionation of crude oils and preparation of a variety of special feed stocks in a single operation can be accomplished by the use of a new pilot plant which has been installed by the engineers of Universal Oil Products Company and which recently was put into operation in Universal's Riverside laboratories.

This new unit which operates at a crude oil rate of about a barrel an hour is completely equipped with automatic control devices and has replaced a number of smaller pilot plants in which distillation of crude oil and preparation of special feed stocks from various cuts was a lengthy step by step series of operations.

Evaluation of the potentialities of the refiner's crude oil is greatly simplified by the new unit, and the cost is substantially reduced because the pilot plant can take a relatively small sample of the refiner's own crude oil and prepare samples of feed stock for various process units at a relatively low cost, whereas previously it has often been necessary to make an expensive full-scale run in the refinery or in several pilot plants to produce the desired feed stock samples.

The pilot plant consists of three more or less distinct sections which can be operated either separately or as one integral unit, the first section consisting of a gas-fired crude pipe still and fractionating column together with two side cut strippers in which are carried out ordinarily crude oil fractionations at atmospheric pressure to produce gasoline, kerosene and light gas oil distillates, leaving a residual reduced crude as crude column bottoms.

The second section of the unit consists of an electrically heated vacuum furnace and vacuum flash tower which can be used either to process crude column bottoms or extraneous topped crude. This section of the unit is equipped with a three-stage steam jet pump and barometric condensers which will permit operations at pressures substantially below those normally encountered in commercial vacuum flashing operations.

The third section of the unit consists of a superfractionating system of two highly efficient fractionators arranged for series operation, so that narrow boiling heart cuts can be prepared. It is frequently necessary to prepare such cuts for charge stock for specialized hydrocarbon conversion processes, such as hydroforming for example. The first of these two superfractionators can be operated in conjunction with the crude column to provide for continuous depropanization or debutanization of the straight-run gasoline from the crude oil.

New Transamerican Representative

W. H. Owens, formerly of Tulsa, has been appointed resident manager in Mexico City for Transamerican Factors, Ltd., oil equipment exporters. Mr. Owens has been active as an oil producer since 1926 when he drilled a number of wells in Kentucky. Later he operated as an independent in the mid-continent and with Robert F. Garland. Later as an associate of W. R. Davis, he spent considerable time in Europe and Africa. He made surveys for the Belgian Exploration Co. in Panama and Colombia in 1939 and now lives in Mexico.

Equipment Bulletin

Allis-Chalmers equipment for the oil industry, built in a maximum range of types and sizes, is described in a new 20-page bulletin released by the company. Products covered include Texrope power transmission equipment, drilling rigs, electric motors, motor controls, transformers, unit substations, generators, shale shakers, blowers, compressors and centrifugal pumps. Described and portrayed are the three types of power units for oil drilling rigs built by Allis-Chalmers. These are Texrope-driven mechanical rigs, electric-mechanical and DC full-electric rigs. Also featured is the company's new line of totally enclosed fan-colled motors in sizes up to 2,000 HP engineered to meet the particular needs of pipeline companies and oil refineries.

Copies of "Allis-Chalmers Equipment for the Oil Industry," bulletin 25B6676, are available on request from Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

Eleven New Tankers Ordered

Construction of 11 new tankers which will be among the largest in the world will be undertaken by the Sun Shipbuilding and Dry Dock Co. The vessels will be 600 feet long with a beam of 82 feet six inches, depth of 42 feet six inches and dead weight tonnage 26,000. The propulsion will be single screw geared turbines and shaft horsepower 12,500, speed 16 knots and cargo capacity 230,000 barrels.

Two of the tankers will be built for the Gulf Oil Corp., two for Standard Oil Co. (N. J.) and seven for Tankers Navigation Co., Inc., to be chartered to Socony-Vacuum Oil Co., Inc.

Boiler Bulletin

A new bulletin covering engineering details of the Vogt Class LE water tube boilers has been published by Henry Vogt Machine Co., Louisville, Ky. Copies are available on request.

Bahrein Production

Production of crude oil in Bahrein during December, 1947, was 882,348 barrels. Production for the twelve months ending December 31 was 9,410,710 barrels.

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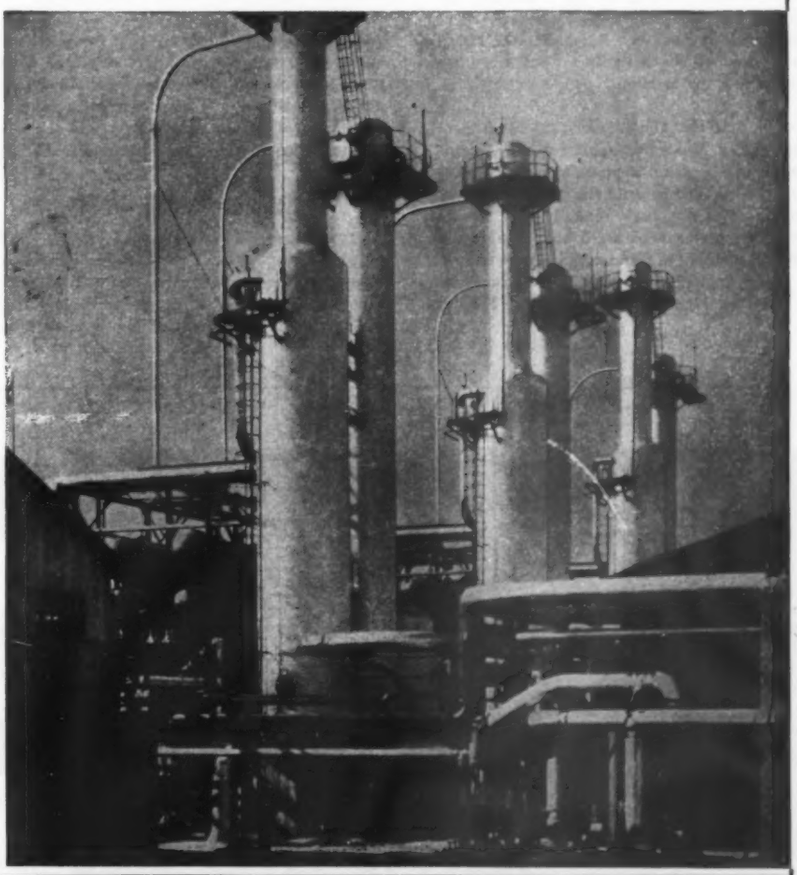

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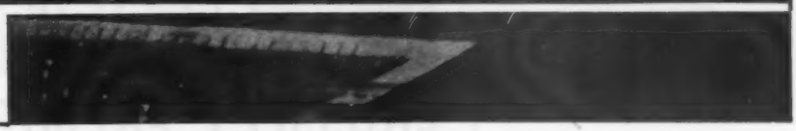


Continental Purchases War Plant

Continental Oil Company has purchased from War Assets Corporation the large 100-octane gasoline plant built during the war by Defense Plant Corporation adjoining the company's refinery at Ponca City. The purchase price was $3,125,000, and Continental will spend approximately a million dollars on the plant's modernization. This will include conversion of kilns to a solid-bed type, installation of equipment to permit concurrent flow of catalyst and vapor and major repairs to other equipment.

The plant was started in 1942 and began production early in 1944. It was built by The Lummus Company and was operated by Continental as lessee during the war. It includes thermal catalytic and retreating units with capacity for cracking 20,000 barrels daily of gas oil and treating 6,000 barrels, feed preparation and gas concentration units of 3,000 barrels daily capacity, an alkylation unit of 3,000 barrels capacity, and aluminum chloride isomerization of 1,500 barrls daily capacity.

Hydrocol Plant for South Africa

First application of the Hydrocol process to the production of synthetic oil from coal is expected to be in South Africa rather than in the United States. At the recent annual meeting of the American Institute of Mining and Metallurgical Engineers, P. C. Keith, president of Hydrocarbon Research, Inc., stated that the first plant will be built in a foreign country but did not indicate the location.

About the same time the Anglo-Transvaal Investment Co., Ltd., announced that it had applied to the government for a license to erect a plant capable of producing 60 million gallons of synthetic gasoline and 10 million gallons of diesel fuel annually. A special company will be organized to build and operate the plant which will cost $48 to $50 million. A. S. Hersov announced at the annual meeting of Anglo-Transvaal that South African rights had been obtained from Hydrocol.

Some months ago Mr. Keith stated that a coal-oil Hydrocol plant to produce 6,046 barrels of gasoline, 1,125 barrels of gas oil and 216,000 pounds of chemicals daily would cost about $43 million to build. It would process 4,454 tons of coal daily and produce gasoline at a cost of about 15 cents per gallon.

Sound Films Portray Steel Processes

Two interesting sound films depicting the manufacture of steel and its utilization by industry have recently been completed for Stewarts & Lloyds, Ltd., well-known British producers of tubular steel. The first film, titled "Thro' the Mill," traces the course of ore from the mine through its casting into ingots and the various processes leading to its conversion into finished products. The second film, "The Tube Age," deals with the worldwide industrial applications of steel tubes. A series of views illustrates their many uses in the petroleum industry in drilling, refining and transport operations. Special shots show oil activities in the Middle East, including distillation and cracking, pipelines, storage depots and marine operations.

Elected Secretary-Treasurer

W. A. Miller has been elected secretary and treasurer of Lane-Wells Company, succeeding Miss B. G. Peters who has retired after fifteen years' service. Mr. Miller joined Lane-Wells in 1945 after five and a half years' service in the Army Air Force where he attained the rank of major. He has been chief statistician since Jan. 1, 1946, and in addition to his new duties as secretary and treasurer, will continue to head the statistical section. Mr. Miller will report to D. S. Jeppson, vice president and controller.

Round-the-World Flight

A round-the-world flight was begun in January by a group of officials of Standard Oil Co. (N. J.), Standard Vacuum Oil Co. and Atlas Supply Co. Plans were to visit scores of cities in 30 countries during the 100-day flight. Plane used was the Atlas Sky Merchant, a DC-4 which has been used since 1946 by Atlas Supply to promote the sale of automotive accessories. Recently the plane made a tour of Latin America.

Among those on the flight were F. H. Bedford, Jr., president; J. E. Partenheimer, vice president and general manager; E. E. Aldrin, aviation director; and J. J. Hall, director of public relations for Atlas Supply. Standard Vacuum men included D. F. Davis, manager of public relations; and E. G. Herberlein, marketing representative. Jersey Standard men included L. E. Brown, Far Eastern representative; W. B. Brown, South American public relations representative; and Harold Corsini, photographer.

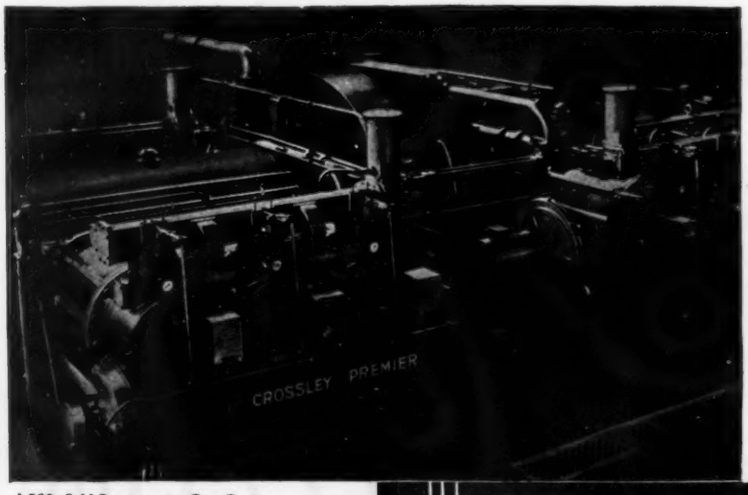
Peron Defines Argentine Oil Policy

On the commemoration of the discovery of oil in Argentina, Pres. Juan Domingo Peron delivered a speech with the purpose of defining the policy of his government regarding oil activities in the country. He stated that the fundamental policy is to achieve economic independence and that government intervention is necessary for the control and guidance of the industry toward this goal. He added that the same policy will be followed in matters of oil as in other basic industries. The state will continue the exploitation of national wealth which is the patrimony of the nation, but will not close its doors to collaboration by others.

As a result of his message the private companies operating in Argentina have resumed their modernization and enlargement work which had been interrupted temporarily on account of rumors that nationalization of the industry or establishment of a mixed enterprise (EMPA) was contemplated.

Production In Great Britain

Production of crude oil in the United Kingdom during 1947 is reported provisionally as 47,000 tons, equivalent to approximately 350,000 barrels.



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To Build Hugoton Plant

Stanolind Oil and Gas Co. will build a gasoline plant in the Hugoton field, Kansas. Construction will start within the next 60 days and will be completed this fall. The plant is designed to process 100,000-150,000 MFC per day from 200,000 acres in the western part of the Hugoton field. Approximately 26,000 gallons per day of natural gasoline and 36,000 gallons per day of butane and propane will be produced by the plant. Cities Service Gas Co. will buy the residue gas.

Attock's New Field in Pakistan

Addressing the annual meeting of Attock Oil Company shareholders in London, Chairman Thomas T. McCreath reported that development of the company's Balkassar field in Pakistan is proceeding steadily and offers promise of offsetting the decline of the older Dhulian field. Initial test of the Sakesar limestone brought in a well flowing 300 barrels per day, which has been beaned to 150 barrels. Completion of the third well proved a large production area. A fourth well has recently been begun.

To Increase Capacity

Socony Vacuum Oil Co. will increase the capacity of its East St. Louis refinery from 21,000 to 30,000 barrels daily as part of its current $45 millions refinery expansion and improvement campaign. Included in the East St. Louis program are a thermal cracking unit and a feed preparation unit for the cat cracker. Enlarged loading facilities are to be built at the Mississippi river terminal.

Crude for the enlarged plant will come through the new 647-mile 20-inch crude line which is being built from Corsicana, Texas, to Patoka, Ill. It will cross the Mississippi at Chester, Ill.

Drilling in Panama

Drilling of the first oil well by the Sinclair Panama Oil Corp. on Colon Island, Bocas del Toro, Panama, was begun August 13 with ceremonies attended by Minister of Finance M. de J. Quijano representing President Enrique A. Jiminez and other Panamanian officials.

To Build Contact for Welding

Black, Sivalls & Bryson, Inc., will mass-produce for welding trade a rotating welding contractor which has been in use in the company's own plants for several years. The rotating welding contractor prevents the ground cables from twisting and snarling. Owing to the high load capacity of the rotating contractor, it is well suited for use with automatic welding machines using high currents. Its rating is better than 4.0 cable. Used in pairs on the ends of cylindrical weldments, the contactor tends to eliminate magnetic interference which otherwise can cause an imperfect weld.

Piping Slide Rule

A new slide rule, designed by Tube Turns, Inc., is proving of great usefulness to piping engineers and others concerned with the satisfactory performance of industrial piping systems. Called the Tube-Turn velocity and pressure drop calculator, it gives two kinds of answers to fluid flow problems: (1) a quick estimate based upon a pipe friction factor of 0.006, and (2) an accurate solution, derived from the estimate by applying a correction factor to the straight pipe losses. The calculator may be obtained at the cost price of 50 cents by writing to Tube Turns, Inc., 224 E. Broadway, Louisville 1, Ky.

Halliburton Buys Canadian Company

Halliburton Oil Well Cementing Company of Duncan, Oklahoma, has acquired the stock of Halliburton Oil Well Cementing Co., Ltd., of Calgary, Canada, which formerly was individually owned by E. P. Halliburton. The Canadian company will retain its title and operating organization unchanged. The parent Halliburton company is the largest in its special field. In addition to its service branches in the United States and Canada, it maintains similar stations in eight foreign countries in both hemispheres.

Develops Stainless Steel Deep Well Pumps

Emsco Derrick & Equipment Co. of Los Angeles, Calif., and Dallas, Texas, has developed a new line of deep well plunger pumps for corrosive and abrasive pumping service. Known as the D & B "Endurall" line, these new pumps are manufactured from a special stainless steel alloy and are available in both rod and tubing sectional liner type. Liners, plungers, balls and seats, cakes and miscellaneous fittings are also available for standard pumps now in service.

New Asiatic Sales Manager

John A. Walstrom has been appointed sales manager of Asiatic Petroleum Corp. to succeed B. P. Coppinger who retired on Dec. 31 because of ill health. Mr. Coppinger had been with Asiatic since 1918. In 1941 he was placed in charge of New York offices of the British Petroleum Board, and in November 1942 he was second to the British Ministry of War Transport as director of the tanker division. He rejoined Asiatic in 1944. Mr. Walstrom joined Asiatic in 1946 after his release from the U. S. Navy in which he served as director of the theater division of the Army-Navy Petroleum Board.

Appoints Canadian District Manager

Alvin B. Geddes, 43, sales representative in the Calgary, Alberta, area, has been appointed district manager in Canada for The National Supply Co., Ltd., with district headquarters at Calgary. Mr. Geddes jointed National Supply in 1943 and was Calgary store manager until last Aug. 2 when he became area sales representative.

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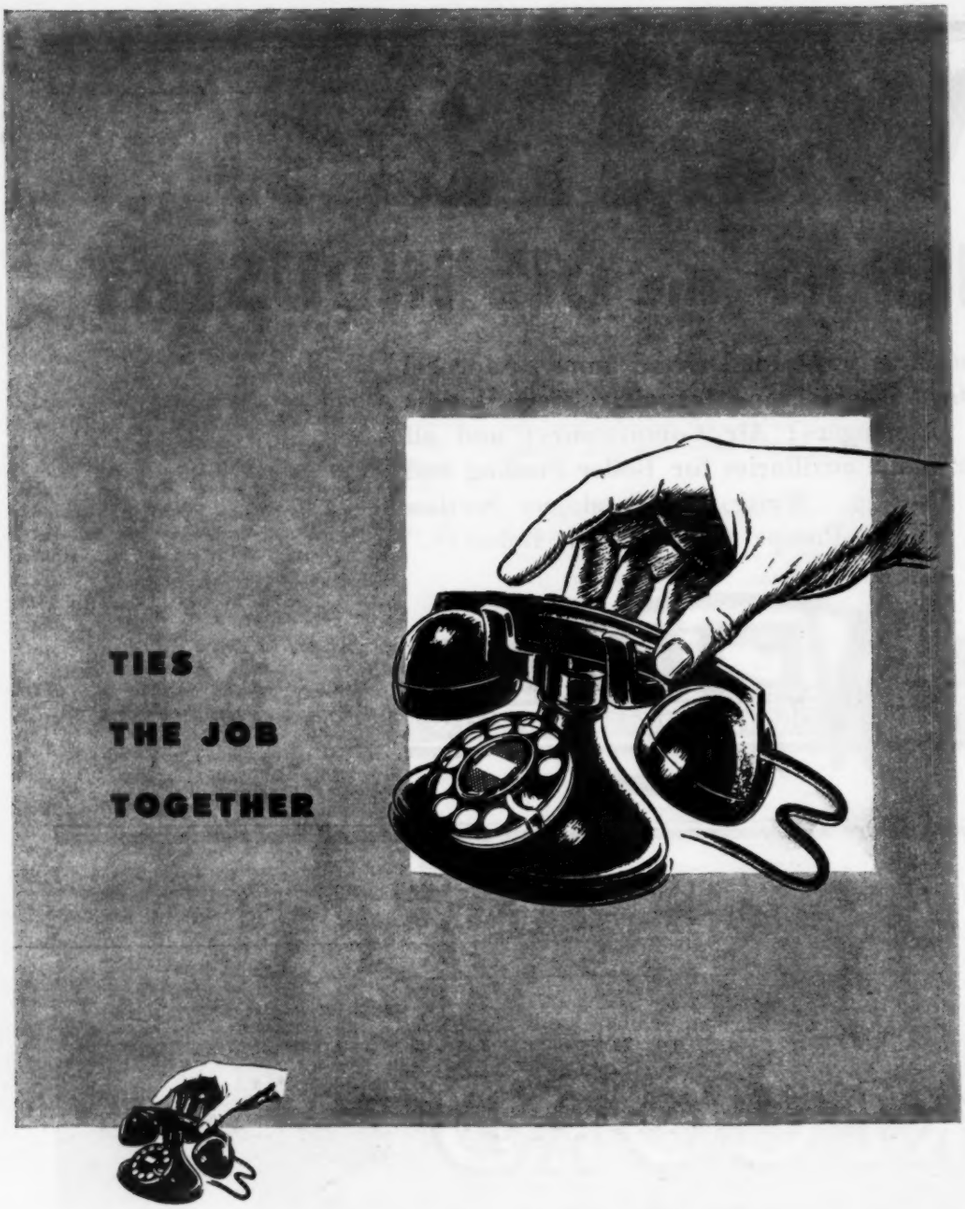

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Kellogg To License Synthol Process

The M. W. Kellogg Co. announced on Feb. 26 that it now is prepared to license the Synthol process to the oil industry. Research developments of Cities Service Co. and Kellogg extending over a period of ten years have combined to give the industry the benefit of two different approaches to the problem of increasing the supplies of synthetic liquid fuels, it was announced.

At a joint press conference A. P. Frame, president of Cities Service Research and Development Corp., and L. H. Harvison, executive vice president of Kellogg, told newsmen of the development of the process and its present availability to industry generally. Cities Service is now surveying its very large gas resources to determine the best location for a Synthol plant but does not plan immediate erection of a commercial installation. Mr. Frame stated that his company prefers to use the steel it can get to drill oil wells until the steel shortage is alleviated.

Mr. Harvison stated that the Synthol process basically is similar to Hydrocol, both being a development of the German Fischer-Tropsch reaction, but that the Kellogg-Cities Service version will vary in details of design. When questioned about synthesis gas production, he stated that either the oxygen or steam-methane method may be used and that ther may be little or no difference in costs of the two methods. Yield was given at about one barrel of synthetic crude per 10,000 cubic feet of gas.

Mr. Frame said that the process now is competitive with crude oil on a dollar cost basis without relying on oxygenated chemical production to carry a substantial part of the load. These chemicals, he said, may be converted to synthetic crude if there is not an adequate market to absorb them all.

The Kellogg-Cities Service combination was a natural result of the complementary activities of both companies over a long period of time, Mr. Frame said. Cities Service has long been interested in the production of chemicals from natural gas, and Kellogg has approached the problem from the standpoint of synthesizing liquid fuel and by-product chemicals from gas.

Initial research by the Cities Service organization in the production of chemicals from natural gas by means of direct oxidation was begun as far back as 1926. The company is one of the largest producers of natural gas in the country, producing 154,000,000,000 cubic feet during 1947. Its reserves are among the largest in the country.

"The first research into the synthesis of liquid fuel by an American firm," Mr. Frame said, "was initiated in the Kellogg laboratories in the middle 30's. Subsequently Kellogg engineers made a thorough field survey in Germany. One of the pioneer contributions by Kellogg was the adaptation of the fluid catalyst principle to liquid fuel synthesis—one of the major processing fundamentals that makes synthesis an economic possibility for America," he said.